The Demand for Money, Adaptive Expectations, and Currency Movements

Söhnke M. Bartram,* Mark Grinblatt,† and Yan Xu‡

Abstract

The cross-section of both raw and risk-adjusted currency returns can be predicted from excess money demand, both contemporaneously and in the future. A novel approach estimates excess demand from panel regressions of M1 on macroeconomic variables tied to both domestic and international transactional requirements. Carry's ability to forecast returns is subsumed by excess money demand. Also, inflation responds to lagged excess money demand.

Keywords: Money supply, monetary policy, currency prediction, inflation
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* Research Fellow, Centre for Economic Policy Research (CEPR), London, UK, and Professor of Finance, University of Warwick, Warwick Business School, Finance Group, Coventry CV4 7AL, United Kingdom. Phone: +44 (24) 7657 4168, Fax: +1 (425) 952 10 70. Email: s.m.bartram@wbs.ac.uk. Webpage: http://go.warwick.ac.uk/sbartram.

† Distinguished Research Professor, UCLA and NBER, 110 Westwood Plaza, Los Angeles CA 90095-1481, Phone: +1 (310) 825 2508, Email: <mark.grinblatt@anderson.ucla.edu>.

‡ Associate Professor of Finance, HKU Business School, Department of Finance, Hong Kong, Email: <yanxuj@hku.hk>.

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1 Introduction

A central thesis of economics is that supply and demand determine equilibrium prices in free and frictionless markets. The principle applies irrespective of whether the price is for a consumption good, a capital good, a service, or a financial instrument. However, economics is more nuanced about the price adjustment mechanism and how it operates dynamically. At the firm level, it seems obvious that excess demand does not immediately cause a jump in prices. A surplus of restaurant patrons on a given night or week does not immediately generate a revision in menu prices. Menu price changes occur only after weeks of turning away patron requests for reservations that are already taken. When remote work became ubiquitous as the 2020 Covid-19 lockdowns were put in place, demand for homes in pleasant remote locations soared. Home prices rose along with the prices of goods to build them like lumber. However, the price increases appeared only weeks and months after the number of available homes appeared to be shrinking.

What happens in financial markets when an analogous set of events occurs? Some might argue that financial instruments are continuously auctioned and are therefore subject to instantaneous price adjustment. However, price changes in financial markets need not be immediate. A stock dealer watching a customer order lift an ask price might subsequently but not immediately raise both the bid and ask prices of the stock. Thus, the speed with which financial markets adjust prices may exceed the adjustment speed for goods and services but the principle is the same.

This paper proposes a model of money demand and relates it to currency returns. Currencies with relatively high excess demand should witness contemporaneous increases in their currency's value. However, we find that much of the price reaction is slow to respond to excess demand, even when estimates of such demand can be computed from information available to traders at the time. This delayed price reaction, which lasts as long as twelve months, cannot be explained by known currency risk factors or previously known currency return predictors. Moreover, the price reaction stems only from information about the macroeconomy that is publicly available to traders. Currency prices do not move with information about the true workings of the economy at the time that is released much later in revisions reported by governmental authorities.

Markets for currencies and currency derivatives are among the world's most liquid markets. The speed with which currency prices adjust to public information should be facilitated by the thousands of speculators who participate in their price formation process. Their trades are aided by sophisticated information feeds and algorithms that help process information. Despite this, exchange rates react to demand with delay, just like restaurant menu and home prices.

We calibrate excess demand with a novel approach: Each month, rolling sixty-month regressions linearly fit a panel of historical OECD countries' M1 data to three major items reported from each OECD economy: GDP, exports, and imports (along with economy-specific and time fixed effects). The linear demand function, with international norms for its coefficients over the 5-year historical period, is motivated by a theory of currency demand. The theory balances M1's convenience in transactions against the opportunity cost of holding wealth in its most liquid forms. The regression's most recent cross-section of residuals represents excess supply. Currencies with the most negative residuals per unit of M1 have the most positive excess money demand and appreciate the most in the next few months; those with the most negative excess demand ratios depreciate the most. Thus, currency movements correlate with relative excess demand for M1.

The effect is large: currencies with the 20% greatest excess demand ratios outperform those with the 20% lowest by 44 bp contemporaneously, and by 38 bp more in the subsequent month. These spreads hurdle most adjustments for risk and anomaly characteristics used in the literature. The benchmarks include carry and momentum, as well as risk attributes tied to an optimal portfolio previously shown to eliminate known currency predictors. Traders can take advantage of our demand estimation approach to earn abnormal profits. However, presumably more accurate signals about money demand from macroeconomic data revisions that traders learn later fail to generate significant profits, even when foreseeable with a "crystal ball."

Not only do currency rates react to our metrics of excess demand, but inflation reacts as well. The economies with the 20% greatest excess demand tend to have significantly more inflation than the 20% with the lowest excess demand, controlling for past inflation as well as growth in M1 from the prior month. The former are also predicted to have the highest currency appreciation. Inflation should make currencies less attractive as investments, generating depreciation in many macroeconomic models. We find the opposite correlation between inflation and contemporaneous currency movements. However, in contrast to currency movements, which respond only to excess money demand derived from information available at the time, excess money demand derived from revised macroeconomic variables is a more potent predictor of inflation.

In theory, currency returns and macroeconomic fundamentals are tightly linked (e.g., Hassan, 2013; Gabaix and Maggiori, 2015; Ready et al., 2017; Cochrane, 2017; Berg and Mark, 2018a). Empirically, however, the link between the two is weak (Mark, 1995), or highly unstable (Rossi, 2013; Fratzscher et al., 2015). Obstfeld and Rogoff (2000) note the surprising lack of an observable relationship between macroeconomic fundamentals and currency returns. Our exchange rate signal is consistent with this literature, in that the signal is correlated with M1 but uncorrelated with M1's macroeconomic regressors: GDP, exports, and imports.

Exchange rate fluctuations have also been notoriously difficult to predict using economic models, a finding that dates back to the time series research of Meese and Rogoff (1983). The latter find that a random walk better predicts exchange rates than any economic variable, including those derived from uncovered interest rate parity, purchasing power parity (PPP), and flexible or sticky-price versions of monetary models. More recent work has found some predictability in the cross-section. Typical predictors, as summarized in Rossi (2013), include purchasing power parity deviations, inflation, output, and productivity. Rossi (2013) concludes that exchange rate predictability is sensitive to the choice of predictor, forecast horizon, sample period, forecasting model, and forecast evaluation method. However, other variables, like carry (Lustig et al., 2011, 2014), output gap (Colacito et al., 2020; Dahlquist and Hasseltoft, 2020), commodity prices (Chen and Rogoff, 2003; Bakshi and Panayotov, 2013), momentum (Menkhoff et al., 2012; Asness et al., 2013), net foreign investment (Jiang, et al., 2023), and external trade imbalance (Gourinchas and Rey, 2007; Gourinchas, Govillot, and Rey, 2017) showed some success at predicting currency returns.

Currency return predictability in the cross-section may also stem from mispricing or microstructure frictions. Burnside (2011), Burnside et al. (2011), Yu (2013) and Bartram et al. (2018) provide behavioral explanations of the carry trade and other currency predictors. Other explanations include currency market microstructure (Burnside et al., 2011), peso problems (Burnside et al., 2009), and crash risk (Brunnermeier et al., 2008).

A trading strategy formed from relative excess demand shows it to be a better exchange rate predictor than other constructs in the literature. The returns to an "excess demand strategy" are relatively orthogonal to risk factors proposed for currency returns. This orthogonality also applies to ad hoc factors formed from return spreads generated by predictor variables. The one exception is interest rates. High excess demand means money is tight, and restrictive monetary policy is generally associated with high interest rates. However, excess money demand is a relative winner in horse races against carry, which has little predictive power compared to the former.

2 Money Demand Model

A money demand model motivates our empirical analysis. Holding currency or demand deposits is costly. Hence, demand for money (here, *M*) comes from its convenience in transactions. The varying size and composition of transactions explain money demand differences across economies.

Money Demand with One Transaction Type. Let C represent the aggregate transaction volume, expressed in units of some numeraire consumption good. Assume a logarithmic utility reward U from having a given amount of money D for transaction volume C. *S*pecifically,

$$U = uC\,ln(D - a\,), \tag{1}$$

with u a parameter for money's convenience and a a non-positive shift parameter. Letting p denote the money price of the numeraire consumption good, the utility reduction R from holding D units of money is assumed to be linear:

$$R = r\frac{D}{p}. \tag{2}$$

The first order condition $\frac{\partial U}{\partial D} = \frac{\partial R}{\partial D}$ determines money demand as

$$D = \frac{u}{r}pC + a. \tag{3}$$

Equation (3) says that money demand depends only on (nominal) transaction volume, pC, the benefit cost ratio of money, u/r, and the shift parameter a. Figure 1 illustrates the solution to the optimization problem holding C constant. The figure graphs money's concave log utility benefit U and linear utility reduction R as a function of money demand. The largest gap between the curved and straight lines is at point $D^{optimal}$, which is where the slopes of the two lines are identical.

If different types of transactions exhibit the same demand for money, setting the supply of money, denoted M, equal to demand determines the price level as

$$p = \frac{r}{u}\frac{(M-a)}{C}. \tag{4}$$

Equation (4) makes the good's price proportional to money supplied in excess of a. Doubling the money supply doubles the good's price only if a is zero. If purchasing power parity holds, price levels determine exchange rates. In this case, if a equals zero, doubling M halves a currency's value.

Figure 2 illustrates the equilibrium with the price of money (in units of the consumption good and thus a real price) on the vertical axis and money quantity on the horizontal axis. The downward sloping curve represents money demand as a function of the price of money in consumption good units. The vertical line is the money supply. The intersection, familiar to every economics student, determines money's price. (If price was the price of the consumption good, the demand curve for nominal money would be upward sloping and linear, with an intercept of a.)

This is barely a model, but it motivates money demand's linear estimation with transaction volume as a regressor. Equation (4)'s primary empirical implication is that two almost identical autarchic economies, differing only in central bank policy, would have cross-country price ratios determined by their relative supply of money.

If, as in Figure 3, the money supply shifts to the right, but price movements are initially sluggish, remaining on the horizontal line through point A, a gap opens between the current price and the equilibrium price (the distance between points B and C). If price adjustment follows the supply shift, we should see the real price of money decline (to point C)—or, equivalently, the price of the consumption good, p, increase in response to the shift. This would decrease currency value in a PPP world. Whether this price shift happens simultaneously, subsequently, or both is an empirical issue to be addressed.

Multiple Transaction Types. Money-facilitated transactions can come from many sources. For example, money facilitates the sale of domestic output to domestic consumers, but some output is also exported to foreigners. Likewise, domestic consumers may purchase imports. Different transaction components, like exports and imports, can have different benefit to cost ratios, generating different money demand coefficients for those components. Since money demand is the sum of the money demanded from each component, generalizing Equations (2) and (3) to isolated decisions about money demand for each component leads to a linear equation for optimal money demand with as many regressors as there are components. Our data allow study of three major components: output for domestic purchases, exports (output for foreign purchases), and imports.

Domestic money is likely to be more useful to foreign purchasers than domestic purchasers of the same domestic output. This is partly because foreigners need to obtain currency that is not their own and implement a foreign currency transaction to buy these exports. It is also because the cost to acquire credit or other money substitutes that facilitate purchases of domestic output is generally greater when the purchaser lives abroad. Imports may generate positive or negative demand for domestic money. At the margin, imports foster sales of the domestic currency to acquire the foreign currency needed to import, but also the offsetting need to post domestic currency as collateral in financial transactions that facilitate imports. (Negative money demand from imports is induced by multiplying the arguments inside the logarithmic function by –1.)

In sum, letting Y be output for domestic consumption, investment, and government expenditure, X be exports, I be imports (all measured in units of goods or services), p^* be the price of the consumption good in the foreign country, and f the exchange rate expressed as units of domestic currency that can be bought for one foreign currency unit, the model's aggregate demand for the domestic currency will be the linear function

$$D = D_Y + D_X + D_I = a + b_Y pY + b_X pX + b_I f p^* I \tag{5}$$

with b_Y and b_X likely positive (with the latter likely larger), and b_I likely negative or smaller than b_Y. In Equation (5), the coefficients on (nominal) output sold domestically, exports, and imports are

$$b_Y = \frac{u_Y}{r_Y} \tag{6}$$

$$b_X = \frac{u_X}{r_X} \tag{7}$$

$$b_I = \frac{u_I}{r_I}. \tag{8}$$

Equilibrium FX prices. Supply equals demand when M and D equal each other: equivalently, when $M - a = D - a$. Generalizing Equation (4), supply equals demand from Equation (5) when

$$(M - a) = p(b_Y Y + b_X X + b_I \frac{fp^*}{p} I). \tag{9}$$

With purchasing power parity (PPP), i.e., $fp^* = p$, the equilibrium conditions are

$$M - a = p(b_Y Y + b_X X + b_I I) \tag{10a}$$

$$f(M^* - a^*) = p(b_Y Y^* + b_X X^* + b_I I^*) \tag{10b}$$

for the domestic and foreign economies, respectively. Equation (10a) says that when the domestic economy has an increase in real transactional demand for money, but the money supply does not increase, the same money supply buys more units of the consumption good by having the domestic money price of the good fall: disinflation. Likewise, an increase in the supply of money alone raises the domestic price of the consumption good: inflation.

Subtracting the log of Equation (10a) from the log of (10b), we obtain

$$ln(f) = -ln(M^* - a^*) + ln(M - a) + ln(b_Y Y^* + b_X X^* + b_I I^*) \qquad (11)$$

$$- ln(b_Y Y + b_X X + b_I I).$$

Equation (11) states that percentage changes in the exchange rate depend on percentage changes in the relative supply of money between the two economies (in excess of *a* and *a** for the domestic and foreign economies, respectively) compared to percentage changes in the demand for money (in excess of *a* and *a**) arising from transactions associated with real output and real imports. A central bank that just targets the commensurate increase in money needed to meet an increase in the aggregate volume of real transactions requiring domestic money keeps prices fixed. PPP ties relative inflation to currency price changes. Thus, the foreign real demand increase generates foreign currency appreciation (i.e., *f* increases).

Dynamics. At this point, there is no excess demand: The domestic and foreign currencies are always in equilibrium. In the absence of other forces, currencies with the largest burst in money demanded over a period will experience the greatest appreciation. However, as the paper's introduction noted, parties to price formation employ rules of thumb, feedback on success, and repetition of similar trades that cause prices to underreact to bursts of demand and supply. To model such price dynamics empirically, we assume that time *t*'s exchange rate *f* (domestic currency per unit of foreign currency) follows the process (justified shortly with further model embellishment)

$$E\left[\frac{\Delta f}{f}\right] = k_t \left(\frac{e}{M} - \frac{e^*}{fM^*}\right) \Delta t, \qquad (12)$$

where k_t is positive, e and e^* are the most recent pair of residuals for the domestic and foreign countries from the regression in Equations (10a) and (10b). Scaling the negative of the residual by the money supply, e.g., $-e/M$ or $-e^*/fM^*$, generates a metric of what we refer to as "excess demand" per unit of money. This will be our key predictor of exchange rate movements in empirical tests.

To summarize Equation (12)'s dynamics, if a central bank observes that transactional demand for money is high, it can increase the supply of money. If the central bank does not increase supply, money will become scarce, just like the restaurant seats portrayed in the introduction. The remedy for this is a free market's increase in money's price. Exchange rates, which reflect the price of a pair of distinct money units, are moved by two currencies' relative excess money demands.

Underreaction Mechanism. The "rules of thumb" that underlie Equation (12)'s expected currency movements can be justified as intuitively plausible. However, one can also model the delayed impact of Equation (12) within the classic "Walrasian auctioneer framework." This requires an additional source of money demand and supply—stemming from money's use as a store of value for speculation or market making. The trades of "speculators," as we term them, augment the demand from money's utility as a medium of exchange. Thus, the domestic and foreign economies can have excess demand associated with the medium of exchange agents, but no excess demand overall. It is the residual from the former agents' demand alone that predicts currency returns in Equation (12), but that residual is linked to the demand of speculators.

Speculators would consider cross-economy differences in the time value of money and risk when making trades. For this reason, empirical study of Equation (12) focuses on the dynamics of forward currency prices adjusted for risk. These speculators also cannot have perfectly elastic demand and be fully rational, forcing adjusted forward currency prices to follow a martingale conditional on public information.[1] Equation (12), by contrast, implies predictable currency movements.

[1] In a fully rational model, currency speculators or market makers would recognize that the forces underlying price determination—Y, X, and I for demand and M for supply—are predictable. For example, over many months, some

Here, we ride the coattails of a literature dating back to Fisher (1911) and Friedman (1968) that employs adaptive expectations to model money and price levels. A version of this, found in Grinblatt and Han (2005), supplements demand for transaction convenience with linear demand based on reference prices. The key here is that the speculator irrationally treats the reference price as fair value for the exchange rate. Speculators' aggregate demand functions for the domestic and foreign currency forwards are of the form

$$D_s = b_s p \left(\frac{f}{V} - 1\right) \tag{13a}$$

$$D_s^* = -b_s p^* \left(\frac{f}{V} - 1\right) \tag{13b}$$

where V is the reference value for the exchange rate, viewed irrationally as a fair value, and b_s is positive and finite. This makes aggregate demand for the domestic and foreign currency from money's convenience and from speculators equal to

$$D = D_Y + D_X + D_I + D_s = a + b_Y pY + b_X pX + b_I f p^* I + \ b_S p \left(\frac{f}{V} - 1\right)$$

$$= a + pd + \ b_S p \left(\frac{f}{V} - 1\right) \tag{14a}$$

and

$$D^* = D_Y^* + D_X^* + D_I^* + D_S^* = a^* + p^*(b_Y Y^* + b_X X^* + b_I I^*) - b_s p^* \left(\frac{f}{V} - 1\right)$$

$$= a^* + p^* d^* - b_s p^* \left(\frac{f}{V} - 1\right), \tag{14b}$$

where d (d^*) denotes real demand for money in excess of a/p (or a^*/p^*) from its convenience as a medium of exchange, i.e., $d = b_Y Y + b_X X + b_I I$ and $d^* = b_Y Y^* + b_X X^* + b_I I^*$.

The log of the exchange rate that sets demand equal to supply is

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central banks tend to have looser monetary policy than others. Currency speculators would capitalize on the long-term predictable effects of a central bank's monetary policy and based on deviations from fair value, smooth aggregate excess demand, so that risk-adjusted forward prices follow a martingale.

$$ln(f) = -\,ln(M^* - a^*) + ln(M - a) + ln\left(d^* - b_S\left(\frac{f}{V} - 1\right)\right) - \,ln\left(d + b_S\left(\frac{f}{V} - 1\right)\right). \quad (15)$$

Equation (15) has a closed form solution, derived in Appendix A1.

Equations (14a) and (14b) imply that, other things equal, speculators' sales and purchases of the foreign currency partially offset the fundamental forces that push a foreign currency above (i.e., $f/V > 1$) or below ($f/V < 1$) its reference value. Equation (15) proves the following:

Result 1: The foreign exchange rate lies between the exchange rate that would exist in the absence of speculators (i.e., $b_s = 0$*), denoted here as* f_d*, and the reference value,* V*.*

Proof: If f is above both f_d and V, the two logged expressions on Equation (15)'s far right are both smaller than they would be with $b_s = 0$, placing f below f_d, a contradiction. The argument works symmetrically with f below both f_d and V.

With adaptive expectations, the reference value for the next date will be some (possibly time varying) convex weighting of the old reference value and the new exchange rate. A foreign currency above its reference value will reflect a currency that generally appreciated, pushing speculators to buy domestic currency and sell foreign currency. Working recursively backwards shows that the reference value is a weighted average of past exchange rates. For a currency below the reference price, the reverse is true. Thus, the reference price acts as an anchor that partially delays currency movements that would occur without the speculators.

In subsequent periods, if M, Y, X, and I, along with their foreign counterparts, do not change, (i.e., d and d^* are constant) the gap between the reference price and the exchange rate will continue to narrow, generating predictable trends in exchange rates. Note from Equation (15), that the percentage exchange rate change and the change in f/V are of opposite sign, implying

Result 2: In the absence of changes to the model's macroeconomic fundamentals M, Y, X, and I, f/V *will move closer to 1 with each passing period.*

Proof: If f_{t-1} is above V_{t-1}, then V_t, date t's reference value, exceeds V_{t-1} because adaptive expectations define how V updates. This implies $f_t/V_t < f_{t-1}/V_{t-1}$ because the reverse inequality leads to a contradiction: Equation (15) would then indicate $f_t < f_{t-1}$. But it is impossible for an f/V above one to have increased if V increased and f decreased. A symmetric argument applies to the case with f_{t-1} below V_{t-1}. This immediately leads to our next result.

Result 3: Absent changes to the model's macroeconomic fundamentals M, Y, X, and I, when $f/V > 1$*, the subsequent changes* $\Delta V/V > \Delta f/f > 0 > \Delta(f/V)$*; when* $f/V < 1$, $\Delta V/V < \Delta f/f < 0 < \Delta(f/V)$*.*

Proof: These inequalities immediately follow from the adaptive expectations update of V, Result 2, and the opposite signs of $\Delta f/f$ and $\Delta(f/V)$ from Equation (15).

Thus, if $f/V > 1$, V and f increase, but f's percentage increase is less than V's. If $f/V < 1$, f and V both decrease but the absolute magnitude of f's percentage decrease is smaller than V's.

In sum, persistence in currency returns arises from the updating of reference values, which lessens the subsequent impact of speculators, holding other things constant. The stickier the reference value (i.e., higher weight on the stale reference value), the longer is the impulse response to the initial shocks to macroeconomic fundamentals. However, if the reference price is constant, and thus perfectly sticky, the only equilibrium is a degenerate one with both f and f/V constant.

Figure 4 illustrates f (solid line) and V's (dotted line) paths assuming V updates with 50% weight on both the new exchange rate and the prior date's reference value. At date 0, the f and V are identical, while at date 1, a macroeconomic shock makes f increase by 3.6% compared to its date 0 value. In the absence of speculators, f's date 1 value would be 5% higher than its date 0 value. (The extreme shock helps to visually separate f and V.) Panel A assuming a single date 1 macroeconomic shock and no subsequent change in macroeconomic fundamentals. Panel B illustrates the average paths of f and V across simulations. Each simulation assumes 50% chance of a 20% increase in the exchange rate due solely to fundamentals and a 50% chance of a 20% decrease in the exchange rate. Figure 4's two panels are virtually identical. Their similarity indicates that when demand or supply shifts are random, expected changes in exchange rates behave like the trajectory attached to zero changes in d, d^*, M, and M^*. It also show that reference value reliance implies underreaction to the macroeconomic shock, reflected in date 1's excess money demand (as we define it) and convergence to the shock's implied equilibrium exchange rate with delay.

Excess money demand, a scaling of Equation (10) and (10b)'s residual, is empirically implemented by a regression that omits speculator demand as a regressor. The regression's residuals corresponds to speculator demand in the "enhanced model." When the enhanced model's foreign currency price, f, is above its reference value, Equation (10b) will exhibit negative excess money demand for the foreign currency that tends to shrink toward zero, *ceteris paribus*. The shrinkage generates foreign currency appreciation—until macroeconomic fundamentals alter the dynamics. Conversely, currencies below their reference values have shrinking positive excess money demand that generates currency depreciation. The reference value anchor only generates underreaction to macroeconomic shocks that move currency prices further away from the reference value. Shocks that move f closer to V have amplified effects due to a reduction of "speculation."

In a model with only two currencies, residuals from regressing M1 on fundamentals sums to zero. Hence, in Equation (12), one currency will have a positive excess demand, and one will have a negative excess demand. We have thus shown that there is a model, consistent with a Walrasian equilibrium, that justifies Equation (12). The model requires that investors not be fully rational, but there is no other way to justify predictable risk- and time-adjusted returns.

With many currencies, a pair of economies can both have excess demand relative to some numeraire currency. However, the currencies in the right tail of the cross-section of residuals per unit of money are likely to be those with positive residuals and those in the left tail are likely to have negative residuals. The former will depreciate against the currencies in the left tail of the cross-section. Equation (12) and the empirical analysis that follows are founded on this insight.

3 Methodology, Sample, and Data

Motivated by the theory outlined above, we assume that M1 demand is a linear function of output, exports, and imports (Equation (5)). We use total GDP rather than the model's "output for domestic use" as a regressor, but this is merely a linear shift in the regressors since GDP differs from the model's Y, but it is a linear combination of Y, X, and I. The shift parameter, a, is allowed to vary across economies as fixed effects. Also, because central banks often synchronize monetary policy to be expansionary or contractionary, while exchange rates depend on relative values for excess demand across economies, we include time fixed effects. We also acknowledge that the coefficients of the money demand equation might change slowly over time as technological advances are adopted and as international norms for money demand change. Accordingly, our empirical implementation of the theory employs rolling panel regressions.

At the end of each observation month *T*, we use a 60-month panel prior to and including month *T* to estimate the cross-section of excess money supply in month *T*. The panel's predicted month *T* values for the supply of M1 represent international norms for the model's transactional demand for money, as estimated from central bank behavior over the 60 months. The underlying assumption is that historical periods that include a full business cycle (here 60 months) have "average central banks" supplying M1 quantities that meet the transactional demand for money without being *relatively* expansionary or restrictive. This means they target a stable price for their money.

In sum, month *T*'s cross section of money demand estimates come from the panel's prediction of M1 supply based on international norms over a full business cycle. The economy varying intercept, *a* (designed to capture unobserved sources of demand, like the dollar's role as a reserve currency), as well as slope coefficients on GDP (*GDP*), Exports (*X*), and Imports (*I*) that do not vary across economies, are assumed to be constant over the 60 months, facilitating estimation.

We refer to a scaling of the latest observation's cross-section of residuals as month *T*'s excess demand "signal," which is relevant to currency returns. The data generate two different signals: the first employs information that a foreign exchange trader would have known at month *T*'s end; the second employs the most up-to-date information about the state of the economy at *T*'s month-end, even if that information became known after month *T*. The first signal is labelled the contemporary vintage signal ("CV"); the second is the final vintage signal ("FV"). If the best estimate of the actual workings of the economy is relevant for currency movements, the FV signal will be more correlated with currency returns. If publicly available knowledge about the economy is more salient, the CV signal will be more correlated with currency movements. The empirical analysis employs three steps, first described in brief and then in more detail.

- **Step 1**: Using months *T* – 59, .. , *T*, estimate the 60-month rolling window panel regression

$$M1_{i,t} = \boldsymbol{a_i} + \boldsymbol{c_t} + \beta_{GDP}GDP_{i,t} + \beta_{EX}X_{i,t} + \beta_{IM}I_{i,t} + \varepsilon_{i,t}, \quad (16)$$

  where $M1_{i,t}$ is an M1 estimate for economy *i* in month *t*, $t \in \{T - 59, ..., T\}$. $\boldsymbol{a_i}$ are economy dummies representing fixed effects from each economy *i*'s unobservable attributes (assumed to be stable over any 60 months) and $\boldsymbol{c_t}$ are time dummies representing fixed effects for the months *t*. The data consist of all 16 countries that have CV values for these macroeconomic variables and include the U.S.

- **Step 2:** To obtain month *T's* signal, divide each element of the panel regression's last (i.e., month *T*) vector of residuals by month *T's* M1 for its respective economy and multiply by –1.

- **Step 3:** Identify any link of month *T*'s signal to month *T* or later currency returns and inflation.

Step 1 (rolling regression) detail. Equation (16)'s variables follow processes that are close to random walks, so we estimate its slope coefficients with first differences: here, quarterly changes of the regression's variables because GDP applies to a quarter.[2] By construction, these regressions omit economy fixed effects. We then substitute the first-difference regression's slope coefficients into a levels panel regression to obtain both the fixed effects for all economies and the panel's last-month residuals. We then update each month as the rolling regression moves forward.

For both the CV and FV signals, we source regressor data from the Original Release Data and Revisions (ORDR) Database of the OECD. We checked the data for outliers by comparing contemporary and final vintages, outliers in terms of magnitude, and outliers for short term

[2] Wooldridge (2010) shows that in these situations, estimating first difference regressions is more appropriate than a conventional panel regression with fixed effects.

negative serial correlation. Outliers were checked against data from Bloomberg. We found one error, which was corrected for our statistical analysis, but is innocuous.[3]

All regressors are translated into U.S. Dollars at concurrent exchange rates. The database contains real time data and the months (referred to as Editions or Vintages) for which the specific data value was the most up-to-date value available to the public. Thus, May 2003's exports may have different values from the time it is first reported (say July 2003), and at later months when May 2003 exports are revised. We know all such dates.

The contemporary vintage's CV signal represents information that hedge funds could trade on. For each regressor, the CV signal's month *t* regression observation is the month *t* vintage of the regressor that portrays the most recent information about economic activity preceding *t*. Thus, if April 2003's exports are first available in June 2003, while May's are available in July, the CV signal would use the June 2003 vintage of April 2003's exports for June's regression observation, and the July 2003 vintage of May 2003's export for July's observation. These would be the most recent export data available to both a trader and a central bank in the regression's observation month. For the FV signal, the regression employs the entire dataset's latest (i.e., final) vintage number of June 2003's exports for June's observation, the final vintage of July 2003's exports for July, etc. Our final vintage is from the April 2020 version of ORDR. Such data provide the economy's actual economic state whereas data known to traders and central banks can only forecast the current economic state from recently publicized states of earlier periods. The data cover 16 currencies in each observation month, i.e., our data set is a balanced panel containing 3,936 currency-month observations over the period November 1999 to April 2020.[4]

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[3] We verified with the OECD statistician that this data error was a decimal point misplacement entry mistake on their part for one Japan observation and that traders accessing data feeds from multiple sources (e.g., the Japanese Ministry of Economy, Trade, and Industry) would have had the correct value at the time.

[4] Regressions requiring non-missing values of various covariates are based on unbalanced panels that are slightly smaller (e.g., in Table 2). While signal regressions include the U.S., we do not exclude it due to its importance as a reserve currency since the regressions include currency fixed effects. Return and return forecasting regressions exclude the U.S. because, as numeraire currency, its return is zero by construction, diluting any results we find.

M1 is not in ORDR's database. We source monthly values for M1 from the Main Economic Indicators database of the OECD, which has only one M1 vintage. Two months is a sufficient lag for when it is publicly known. For both signals, we use M1 reported for the observation month instead of lagged M1, except for the last two rolling regression observations with the CV signal, for which traders need to estimate M1. We assume traders use an AR(2) estimate to predict each regression's last two M1 values.

The FV signal treats M1 timing differently from its three ORDR regressors. The reason is that central banks establish peer implied norms based on their information and are likely to have private information about the M1 they supply. However, central banks likely possess the same information as traders about GDP, exports, and imports. Traders running CV signal regressions are trying to establish central bank reactions to GDP, Exports, and Imports. Hence, they must use public information at month *T*'s end to best estimate what central banks knew in each of the 60 months prior to and including *T*. In contrast, the FV signal does not generate a feasible trading strategy. It uses the actual M1 for all 60 observations along with final vintage values for the three ORDR variables to estimate its rolling window panel regressions.

GDP is reported for a quarter but can be revised in any month. In rare instances, quarterly GDP is in annualized units. We convert any annualized GDP values to quarterly equivalents by dividing the values by four, and then compute monthly GDP regressor observations in a manner that is consistent with the rules for the CV and FV signals above.

Step 2 (regression residual) detail. Each month *T* is associated with two signals, CV and FV, and thus, two panel regressions associated with the 60 months ending in month *T*. The pair of residual vectors from each panel regression's last month, *T*, is scaled— dividing the residual by the negative of M1—to proxy for excess demand in month *T*. CV signals can be implemented from public information at the end of month *T*, whereas FV signal better characterize the actual workings of the month *T* economies but use information that is not yet known.[5]

Step 3 (return correlation with signal). The empirical analysis uses monthly data from excess money demand signals at *T*'s month end to predict exchange rate changes in the signal release month *T* (contemporaneous return), or in the following months (*T* + 1, referred to as the "next-month return" and later). Following the literature (e.g., Chernov et al., 2022; Okunev and White, 2003), currency *i*'s month *t* return is the percentage difference between the spot exchange rate at month *t*'s end, $f_{i,t}$, and the one-month forward exchange rate at month *t* – 1's end, $F_{i,t-1}$:

$$R_{i,t} = \frac{f_{i,t} - F_{i,t-1}}{F_{i,t-1}}. \tag{17}$$

F and *f*'s units are expressed as dollars bought per unit of foreign currency.[6] The strategy that earns this profit is a zero-cost investment in a forward contract. Unlike spot-only returns, currency returns from forward contracts are not distorted by cross-currency differences in the riskless time value of money or convenience yields: Only differences in currency risk premia affect currency returns from forwards. Assuming covered interest parity and no convenience yield, the forward contract return is the spot currency return adjusted by the risk-free interest rates of the two currencies being exchanged. Since the latter rates are known, unanticipated changes in the forward currency return are entirely driven by unexpected changes in spot rates. For this reason, and expositional simplicity, we often refer to Equation (17)'s ratio as just the "currency return."

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[5] We construct month *T* excess money demand for each of 187 months: October 2004 to April 2020. The sample consists of 16 currencies including the U.S. Dollar. We treat the Euro area's macroeconomic fundamental as if it were one country by summing all regression variable values across Euro zone countries. Our sample starts after the Euro's introduction and the beginning of the ORDR database. Aggregate fundamentals for the changing composition of Euro area member states range from 11 to 19 countries depending on the observation month. There are 16 currencies each month with both the CV signal and the FV signal. No observations are omitted or winsorized. For the CV signal, there are a small number of cases where countries lack GDP data in the ORDR database at the beginning of the sample period. In this case, we fill in missing values using data from the World Bank with a one-year lag for the CV signal. For other fundamental variables, money supply, or currency price (spot or forward), which have prior data, missing values, if any, are replaced by the most recent prior value for the same variable.

[6] As the numeraire currency, the U.S. dollar has a zero return and is therefore excluded from the Step 3 portion of the analysis, leaving 15 currencies with returns. Results using a currency index (as in Chernov et al., 2023) are similar to those from our use of the U.S. Dollar as numeraire.

(Prior literature sometimes refers to Equation (17) as the currency "excess return" because it approximates the spot return in excess of the risk-free rate difference under covered interest parity.)

We source daily spot exchange rates and daily one-month forward exchange rates from DataStream. Currency forward and spot prices are DataStream's mid-point exchange rate quotes.

Controls for risk and other FX return predictors. To control for known predictors of currency returns, we employ panel regressions and factor model time-series regressions. The panels regress returns from currency forward contracts (Equation (17)) on the CV or FV signals (or quintile dummies for the signals), control variables, and month fixed effects, δ_t:

$$R_{i,t} = \gamma_0 ExcessMoneyDemand_{i,t-k} + \sum_{j=1}^{J} \gamma_j ControlVariable_{i,j,t-1} + \delta_t + e_{i,t}, \quad (18)$$

with k denoting contemporaneous (k = 0) or next-month (k =1) return analysis, respectively. Control variables include the percentage changes in money supply measures over month t – 1 and other commonly used predictors of currency excess returns such as carry, currency momentum over the past 1, 3, and 12 months, a filter rule combination, dollar exposure, term spread, output gap, currency value, and Taylor Rule value—all measured at the end of month t – 1. (Appendix Table A1 provides more detail on these controls.) Driscoll-Kraay (1998) cross-sectional and time-series dependent robust standard errors are used to calculate t-statistics.

For both the non-parametric panel regressions and factor regressions, we sort currencies into equally weighted quintile portfolios based on the contemporaneous or prior-month signals with Quintile 5 representing the largest percentage excess demand. The extreme quintile difference in intercepts from factor model time-series regressions are analogous to the panel regression's coefficients on excess money demand Quintile 5. Factor models regress the time series of one-month returns (Equation (17)) of Quintile q in month t on contemporaneous risk factors:

$$R_{q,t} = \alpha_k + \sum_{k=1}^{K} \beta_{qk} RiskFactor_{k,t} + \varepsilon_{q,t}. \quad (19)$$

Risk factors are alternatively the dollar risk factor and the carry trade risk factors from Lustig, Roussanov, and Verdelhan (2011)[7], the global imbalance factor (Della Corte, Riddiough, and Sarno, 2016), an output gap factor (Colacito et al., 2020), a sovereign risk factor (Della Corte et al., 2021), and the unconditional mean-variance efficient factor ("UMVE", constructed and graciously provided to us by Chernov, Dahlquist, and Lochstoer (2022). The most comprehensive model features a combination of all six of the factors from the five factor models. Heteroscedastic-robust standard errors are used to calculate *t*-statistics (as residual serial correlation is negligible.)

Finally, we analyze the panel of monthly inflation rates—the growth rates of monthly Consumer Price Index values from the ORDR database. These inflation rates are regressed on excess money demand and other variables. The approach is similar to Equation (18) but with a different predictor variable on the regression's left side. Appendix Table A1 defines all variables.

4 Results

4.1 Summary Statistics

Table 1 reports the time series average of the cross-sectional means, standard deviations, minimums, maximums, and correlations with CV of several monthly variables, both for the overall sample and (with cross-sectional means) for quintiles sorted by the CV signal. (Result are highly similar for the FV signal sort, except for returns.) It also includes time series averages of the extreme quintile spreads (equally weighted within quintiles). The variables include the contemporaneous and next-month forward (Equation 17) returns. These currency returns, expressed in percent per month, show the quintile of highest excess demand currencies outperforming the lowest quintile by an average of 44 bp per month in the month of the signal and by 38 bp in the month after the signal. These represent approximately 5% annualized return differences and are statistically significant at the 1% level.[8] The *t*-statistic of the prior-month signals return spread is 2.51,

[7] Source: https://gsb-faculty.stanford.edu/hanno-lustig/files/2022/05/CurrencyPortfolios.xls.

[8] Although unreported, no similar effect exists for spot currency returns, which are complicated by interest rate differences across currencies. Since no money is required to purchase a forward contract, interest rate differences do not need to be accounted for here.

which corresponds to an annualized Sharpe ratio of 0.56.

Table 1's contemporaneous and next-month return spreads have average correlations with the CV signal of 0.07. The percentage difference between forward and spot exchange rates, known as the carry trade control, has a far larger average correlation with the CV signal (0.34).[9] Large spreads between the extreme CV quintile values are also evident for most of the of other variables listed in Table 1, which consist of known or theorized predictors of currency returns. Indeed, almost all the variables have extreme CV signal quintile spreads that are significant, although *t*-statistics for the non-return variables are biased due to their serial correlation. The *t*-statistics for returns and return spreads lack this bias under the null of market efficiency. These findings suggest that it is necessary to control for other factors when analyzing whether excess money demand predicts current or future returns.

4.2 Currency Returns (from Forward Contracts) and Excess Money Demand

Tables 2 and 3 study excess money demand's relationship with currency returns. Table 2 reports findings from panel regressions with month fixed effects and Driscoll-Kraay (1998) standard errors. Because Table 2's regressions have month fixed effects and because there is far more regressor variation in the cross-section, excess money demand's ability to predict returns must stem from its cross-sectional relationship with returns. We later study factor model regressions, which are more commonly used to control for potential risk factors that influence these returns.

Panel Regressions. Panels A and B of Table 2 focus on contemporaneous currency returns; Panels C and D on next-month returns. In terms of signals, Panels A and C take excess money demand from the CV signal, while B and D are from the FV signal. The top part of each panel employs quintile dummies for excess money demand while the bottom represents the same regressions' coefficients and test statistics for parametric excess demand (not listing the controls'

[9] While not reported in the table, the extreme quintile return spreads are positive 57% (contemporaneous return) and 55% (next-month return) of the time, respectively.

coefficients for brevity). Panel C is the only panel that can properly assess market efficiency, as traders can implement the CV signal at the end of month T and earn returns in month $T + 1$.

Each of Table 2's coefficients come from a panel regression of currency returns on either excess demand quintile dummies (from one of two signals) or the scaled excess demand residual itself and (depending on column) a host of other currency characteristics known to predict returns as well as time fixed effects. These characteristics are measured at the end of month T, when the signal is constructed, and include momentum over three past return horizons, carry (described earlier), the change in M1 (or M2) over month T, a filter rule combination, dollar exposure, term spread, output gap, currency value, and the Taylor Rule. See Appendix Table A2 for details on the distribution of these variables. In contrast to Table 1, every observation gets equal weight in Appendix Table A2's calculations.

Next-month returns are computed beginning the second day of month $T + 1$ to ensure that any time differences across the world's venues for trading different currencies allow the CV signal to be implemented. For apples-to-apples comparisons, we also omit the first day of month T for trades based on the contemporaneous signal. Skipping also ensures that common noise does not exist between measured inputs for the returns and either signals or controls. The latter cannot be implemented unless traders privately know information at the beginning of month T that is publicly known later in the month (in the case of the CV signal) or publicly known at some future date (sometimes months later) for the FV signal.

All 112 specifications of Table 2 show that currencies with high excess demand have high abnormal returns, controlling either individually or jointly for other known or suspected determinants of exchange rates. In 50 of the 56 specifications from Panels A and C (the CV signal), the effect is significant at the 5% level. Generally, Panel A's contemporaneous return coefficients on excess demand are slightly larger than the corresponding next-month return coefficients in Panel C. At first glance, the greater contemporaneous return effect is unsurprising. If markets are efficient, currency movements from excess demand should occur instantaneously. Since CV signals update information from the prior month, we expect month T currency returns (Panel A) to be sensitive to the update. However, the reduction in signal efficacy in the next month (Panel C) is small and represents an efficient markets anomaly, as traders implementing the CV signal at month T's end earn large returns in the next month. For example, Panel C shows that Q5 currencies outperform Q1 currencies next month by 30–50 bp per month, depending on the specification.

What is surprising is that the FV signal in Panels B and D only reaches the 5% significance level in 1 of the 56 specifications. Final vintage numbers represent a more accurate portrait of the economy at the end of month T. However, no significant profits emerge from having a crystal ball and being able to know revised values of GDP, Exports, and Imports as early as the beginning of month T. The only explanation for the greater efficacy of the CV signal is that what currency traders know may be more important for currency movements than more accurate undisclosed information about the economy, which often remains undisclosed for months.

So why is advance knowledge of the CV signal profitable? Traders know the CV signal with certainty by month T's end. They can surely act on the signal to earn returns in month $T+1$ if currency prices react slowly. However, they can act on some version of the CV signal even earlier. For example, some of the CV information may be released in the middle of month T, generating some trader reaction. Traders may also have estimates or leaks from private sources about the CV signal components, which they act on prior to month T's end.

The four specifications in Panels A and C with all controls (Column 14) have coefficients on the CV signal that are significant at the 5% level or just miss 5% significance. The least significant coefficient occurs in Specification 3, where excess money demand competes with carry as an explanation for returns. Whether carry accounts for the efficacy of an excess money demand signal or whether excess money demand explains the carry effect requires more investigation. We will revisit carry vs excess money demand's marginal impact on returns. We now study factor models.

Factor Models. Factor models represent an alternative and more common way to adjust currency movements for known predictors, often tied to risk. The intercepts or alphas in the factor models represent the abnormal returns of the excess money demand quintiles. We employ six different factor models to assess whether factor exposures explain our results. Table 3 shows intercepts (alphas), slope coefficients (often omitted for brevity), and *t*-statistics from time series regressions of monthly portfolio currency returns on the six sets of risk factors. Table 3's four panels parallel Table 2's panels. Panels A and B's contemporaneous returns focus on the returns in the month the signal is obtained, while C and D focus on trades implemented in the month after observing the signal. A and C employ CV signals, while B and D use FV signals.

The factor models include Lustig et al.'s (LRV, 2011) two-factor model (a dollar factor and a carry factor), the global imbalance factor model of Della Corte et al. (2016), the output gap factor model of Colacito et al. (2020), the sovereign risk factor model of Della Corte et al. (2021), the unconditional mean-variance efficient (UMVE) factor model of Chernov et al. (2022), as well as a combination of all six factors from these five models (the combination model).

As in Table 2, Panels A and C of Table 3, based on the CV signal, show large and significant Q5 – Q1 alpha spreads, both contemporaneously and in the next month, with contemporaneous spreads a bit larger. These spreads range from 29 to 45 bp per month. The lowest of these spreads, the next-month return with the LRV model in Panel C, narrowly misses 5% significance. This is a consequence of excess money demand's correlation with carry. The 11 other alpha spreads are highly significant—at the 1% level in the 8 cases that exclude the carry factor. By contrast, none of the FV signal's 12 alpha spreads in Table 3 Panels B and D is significant at the 5% level. As with Table 2, what FX traders think they know about the economy rather than a more accurate portrayal of the economy's true state is what moves FX markets. What is striking, as with Table 2, is that some of the FX market moves occur with a lag.

To investigate the extent of the lag, Figure 5 plots the Q5 – Q1 currency return spread for a CV signal received at lags varying from 0 to 12 months. The 0-month and 1-month signal lags have different returns than those in Table 1 because (for apples-to-apples comparisons across lags) the returns start 12 and 11 months later than the two returns spreads in Table 1. As the figure indicates, spreads weaken as the signal lag moves from 0-4 months, but as the signal becomes even more stale, spreads start to rise again. Even with a 12-month lag, CV's money demand signal earns a 34 bp per month extreme quintile spread. The cumulative effect is impressive, suggesting a long-short strategy in one-month currency forwards, held for a year in the same basket of currencies, earned more than 3.3% per year based on public information.

4.3 Carry vs. Excess Money Demand

Tables 1–3 show that excess money demand, computed from CV, is correlated with both contemporaneous and next-month returns. However, the efficacy of the CV signal diminishes when we include carry or a carry factor as a control, in part because carry correlates with the CV signal. Table 4 runs horse races to help assess whether the CV signal's ability to predict next-month returns is due to carry. Panel A repeats the panel regression methodology of Table 2 Panel C. The left half analyzes quintile dummies for both CV excess money demand and carry to predict next month returns. The right two columns run the same pair of horse races with parametric versions of the two predictors. The latter are the same regressions at the bottom of Columns (3) and (14) in Table 2 Panel C, however, they now show carry's coefficient and *t*-statistic. Thus, Table 4 Panel A's odd-numbered columns' regressors are carry, excess money demand, and time fixed effects, while the even-numbered columns add the full set of controls.

In Panel A's left half, we can compare coefficient magnitudes. The excess money demand Q5 coefficient is eight (column 1) to sixty-five (column 2) times larger and far more statistically significant than the Q5 coefficient for carry. In the parametric regressions of Panel A's right half, the coefficients are not comparable, but we can compare *t*-statistics. Without the additional controls (Column 3), the *t*-statistic on excess money demand is 1.69, which is significant at the 10%

level, while carry's *t*-statistic is 1.17 and insignificant. With the other controls (Column 4) the *t*-statistics on excess money demand and carry are 2.28 and 1.00, respectively.

Table 4 Panel B employs the factor model methodology of Table 3 Panel C to run carry vs. excess money demand horse races. The first of four regressions repeats the 2-factor LRV row from Table 3 Panel C. The next row runs the same regression but with carry as a single factor. For apples-to-apples comparisons, the Table 4 Panel B's carry factor is the extreme quintile return spread from carry-sorted portfolios. (Table 3's carry factor, by contrast, is from LRV.) The bottom two regressions study alphas with quintiles sorted by the carry signal and use the extreme quintile CV return spread from Table 3 Panel C in place of the carry factor.

The first regression shows (as did Table 3 Panel C) that the CV excess money demand signal generates an LRV-adjusted alpha spread of 32 bp per month, which is significant at the 5% level.[10] By comparison, the pseudo-LRV factor model in the third regression that replaces the carry factor with the CV return spread factor has a small insignificant alpha spread for carry (6 bp, $t = 0.35$).

The alphas spread between CV's extreme quintiles are similar (31 bp, $t = 2.08$) to the LRV alpha spread when carry is the only factor. By contrast, carry's extreme-quintile alpha spread, controlling only for the CV factor, is 4 bp, with a *t*-statistic of 0.21. In sum, the CV signal of excess money demand predicts future currency returns; the effect is weaker but either significant or close to significant when carry is controlled for. However, the reverse is not true. This suggests that excess money demand is a cleaner signal of future returns than carry and perhaps accounts for carry's ability to predict currency returns.

4.4 Excess Money Demand as a Forecaster of Inflation

Money supply that exceeds transactional needs, as benchmarked by international monetary norms (i.e., negative excess demand), depresses a currency's value. Here, we analyze whether excess demand or supply also leads to inflation. The left half of Table 5's two panels regress month $t + 1$'s

[10] When carry is constructed from only our 15 currencies, CV's alpha spread is larger and more significant.

inflation rate on month t excess money demand or its quintile dummies and several controls. In lieu of excess money demand, the right half of Table 5's two panels report coefficients on excess money demand's simplest inflation prediction—with the latter obtained in the first step of a two-step regression: regressing only on excess money demand or its quintiles without any controls.

Each of Table 5's panels report coefficients and test statistics across 16 different specifications. All regressions include month fixed effects. Panel A employs the CV signal, while Panel B uses the FV signal. In each of Table 5's top halves, both the quintile of currencies with the highest excess demand and, to an even larger extent, the month t inflation prediction of all quintile dummies for inflation in month $t + 1$—referred to as "Expected Inflation"—significantly predict inflation in month $t + 1$. In Table 5's bottom halves, which do not report coefficients on the controls for brevity, both parametric excess money demand and Expected Inflation, predicted from parametric money demand alone, significantly predict inflation irrespective of the controls added.

Table 5 offers several insights. First, in contrast to prior tables' predictions of currency movements, the FV signal is a better predictor of inflation than the CV signal. Second, from Specifications 4 and 8, month $t + 1$'s unexpected currency movements do not correlate with inflation once we control for either excess money demand or predicted inflation from excess money demand alone. Third, the signs on the coefficients of excess money demand for both currency returns (Tables 2 and 3) and inflation (Table 5) prediction are positive. The second and third findings imply that currency returns, and inflation tend to move in the same direction even though appreciating currencies generate relatively cheaper imports.

The puzzling link between currency returns and inflation could be the consequence of central banks' reaction functions. One possibility is that central banks with high expected next-month inflation tighten M1's supply. The tightening supply causes inflation to diminish at some distant future date but creates a scarcity of M1 that causes the central bank's currency to appreciate.

Thus, the regressions may only be picking up cross-sectional differences in what central banks perceive is a long-run problem requiring an immediate fix. Regression never establishes causation and this conjecture has Table 5's causation arrow reversed. However, comparisons of Panels A and B's coefficients offer evidence against this explanation: inflation's predictability is greater with the FV than the CV signal, even though central banks know only the CV signal's values for GDP, exports, and imports.

5 Conclusion

Currency prices, like every traded good or service, are driven by supply and demand. Using a novel approach to estimate money demand, we present evidence from OECD countries of predictable currency price movements. The predictability applies to currency returns from forward contracts expressed either as raw returns or as returns adjusted for commonly used risk factors and predictor variables. The currency movements occur both contemporaneously with the excess demand signal and when implemented with a lag. It is the signal known to traders (which is based on preliminary values) rather than revised numbers for macroeconomic fundamentals that correlate with contemporaneous and next-month currency returns. This is an unusual finding in that the final revised numbers more accurately reflect the true state of an economy.

The paper also developed a model that is consistent with these empirical findings. The model's irrational speculators represent one mechanism for slow reaction to fundamental changes in the economy. Something less than full rationality is required to explain why risk-adjusted forward contract returns are predictable. These "speculators" could simply be agents who use rules of thumb to update prices so that new equilibria are achieved over time. Their existence is no more farfetched than the artifact of the Walrasian auctioneer who observes all demand and supply functions, then solves a complicated fixed-point problem to achieve each new equilibrium. That auctioneer represents the hotel manager, airport FX kiosk owner, forward currency pit trader, or market maker who figures what to charge each instant for the currency trades in which they participate.

One can also introduce rational investors into the model provided that these investors have limited capacity to alter currency prices. They will tilt the equilibrium derived in this paper towards one with currency returns that better resemble changes in cross-economy differences in pricing kernel changes, as asset pricing theory suggests. However, their introduction will not fundamentally alter the comparative statics of the simpler model we present here.

Finally, the model's validity does not hinge on the PPP assumption *per se*. Forces causing PPP deviations or convergence to PPP are second order effects, at least compared with the supply and demand for money. This seems plausible in that supply-demand imbalances are likely to resolve quickly. Other factors, like trade frictions, resolve slowly, and have been unsuccessful at explaining nominal currency movements.

Because currency markets are so liquid, financial economists generally believe that currency movements should instantly reflect public information. We present evidence to the contrary, hoping to spur further investigation into the dynamic process that leads prices to their equilibrium state. Alternatively, there may be risk factors in currency that have yet to be discovered, but which we have omitted. If the latter turns out to resolve this anomaly, the paper will have at least spurred discovery of new sources of risk in exchange rate movements.

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Figure 1: Utility and Utility Reduction as a Function of Money Demand

The figure shows the relation between utility (U, solid line) and utility reduction (R, dotted line) as a function of money demand (D). $D^{optimal}$ is the level of money demand that creates the largest difference between both curves.

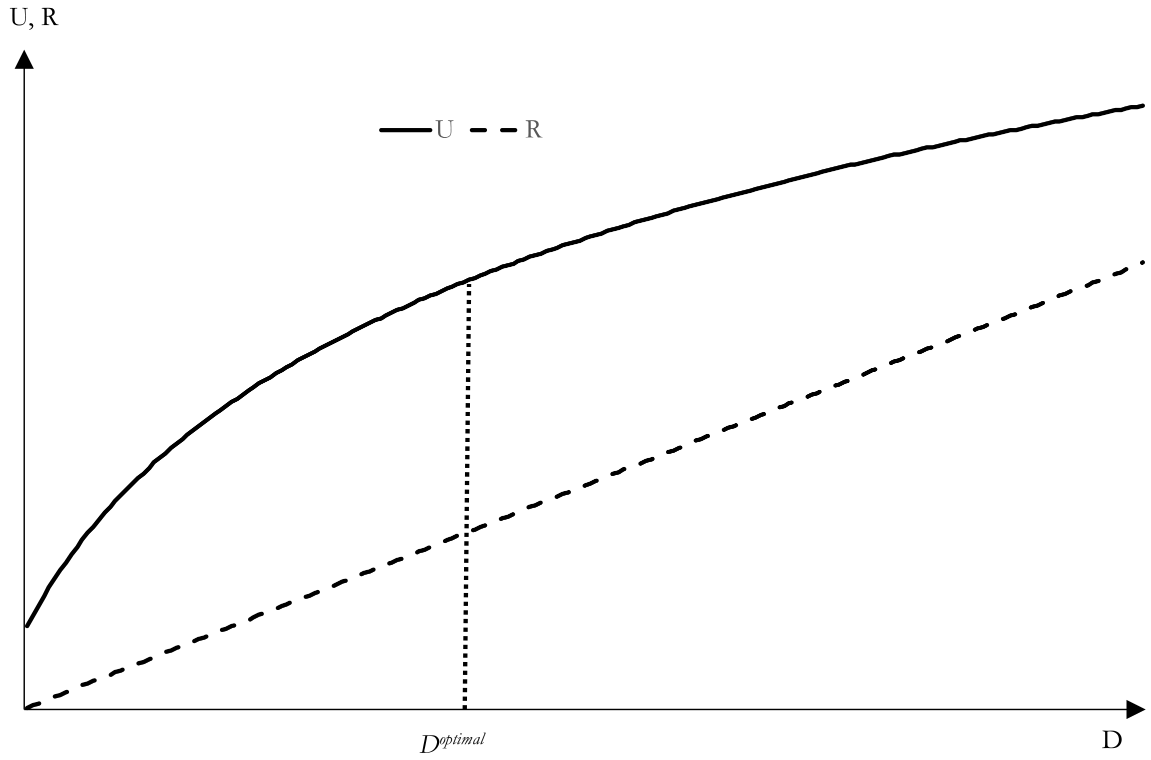


Figure 2: Money Demand and Supply

The figure shows the relation between the price of money as a function of the units of money. The solid line shows the demand for money (D), while the dotted line shows the supply of money (M).

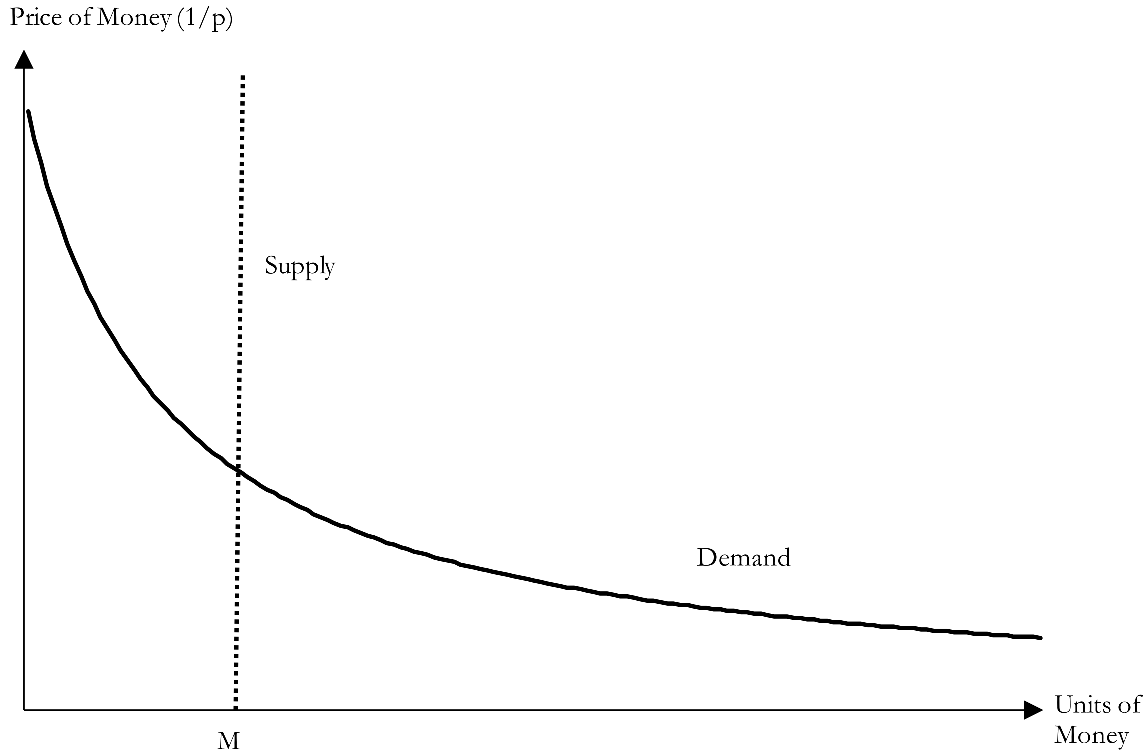


Figure 3: Shift in Money Supply

The figure shows the relation between the price of money as a function of the units of money. The solid line shows the demand for money (D), while the dotted lines show the supply of money shifting from one level (M) to a higher level (M'). The horizontal solid line in blue shows the equilibrium price of money before the shift in money supply.

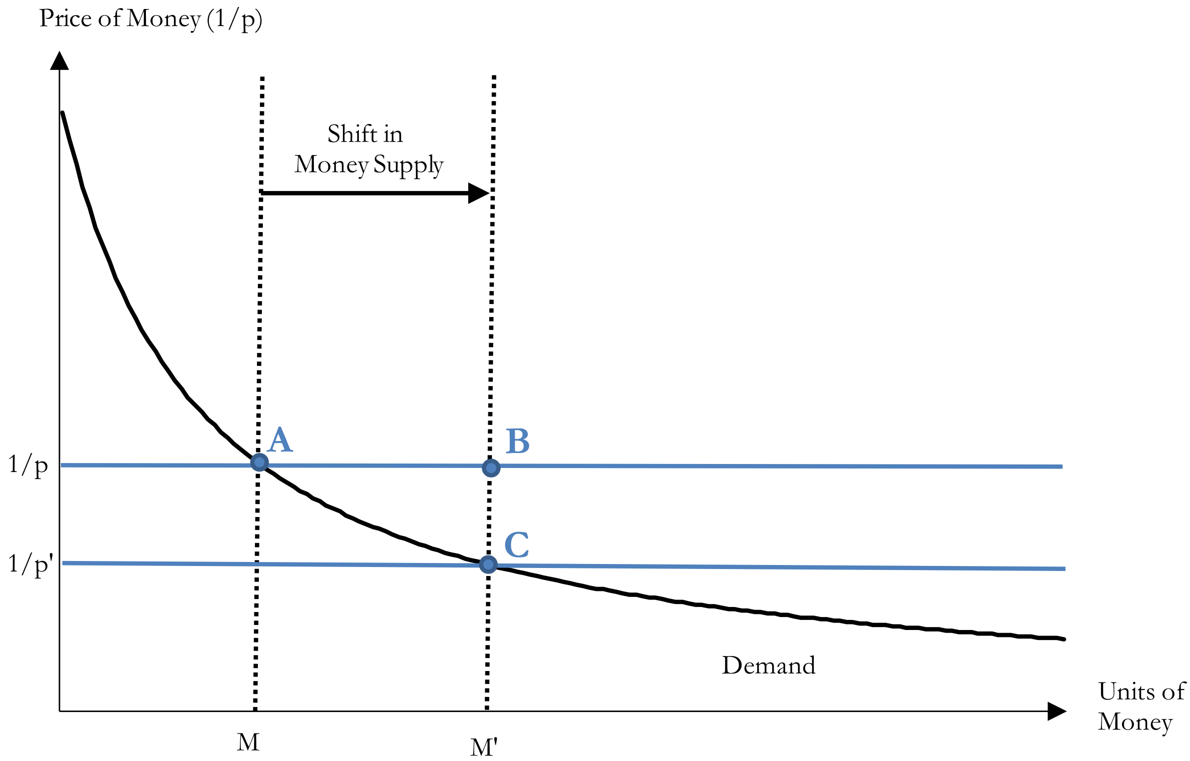
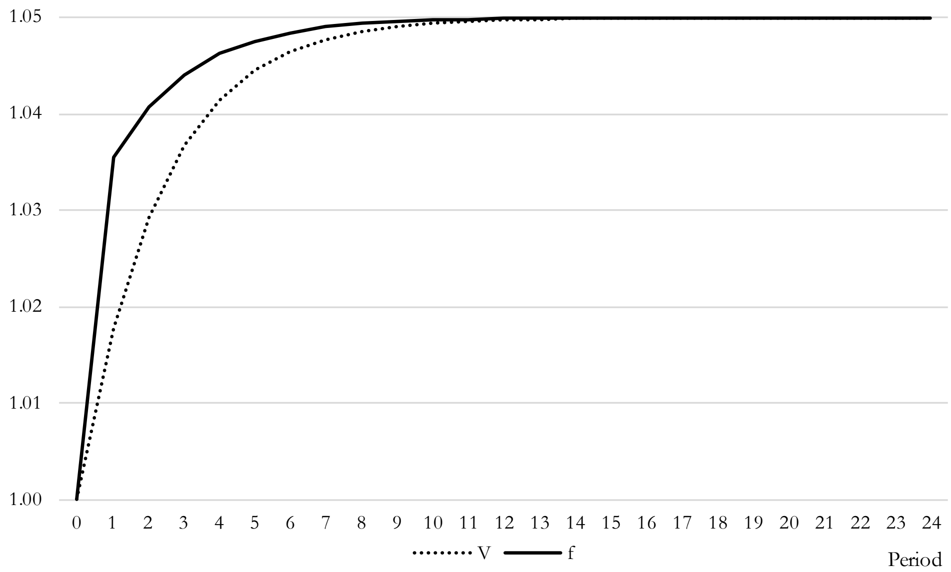


Figure 4: Impulse-Response Functions of Exchange Rates and Reference Values

The figure shows the impulse-response functions of exchange rates and reference values following a shock to the fundamental of both countries, i.e., *d* and *d**. Panel A illustrates the path of the exchange assuming that there is a single macroeconomic shock at date 1. It plots the path of the exchange rate and its reference value assuming no further change in macroeconomic fundamentals. At date 0, the reference value and exchange rate are identical, while at date 1, the shock increases the exchange rate to 3.6% above its date 0 value. In the absence of speculators, the exchange rate would have been 5% above its date 0 value. The reference value updates with 50% weight on the new exchange change and 50% weight on the reference price. Panel B illustrates the path of the exchange rate and reference value as the average across simulations in which after date 1, there is 50% chance of a 20% increase in the exchange rate due solely to fundamentals and a 50% chance of a 20% decrease in the exchange rate.

Panel A: Single Shock



Panel B: Multiple Shocks

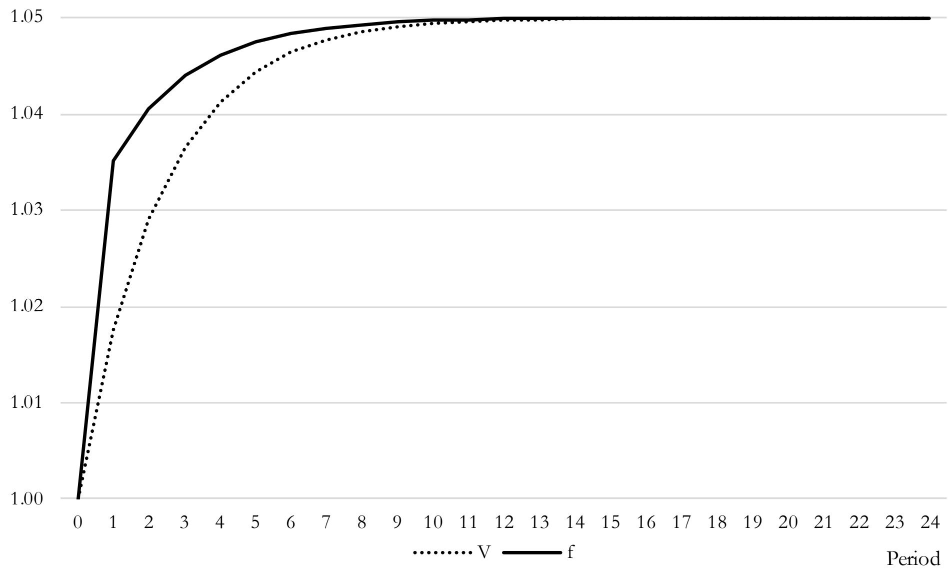


Figure 5: Decay of Signal Efficacy

The figure shows the quintile spread in currency excess returns between equally weighted portfolios of currencies with high and low excess money demand. The spread is shown for alternative lags of the CV signal between 0 and 12 months. The sample period is November 2005 to May 2020. All variables are defined in Table A1.

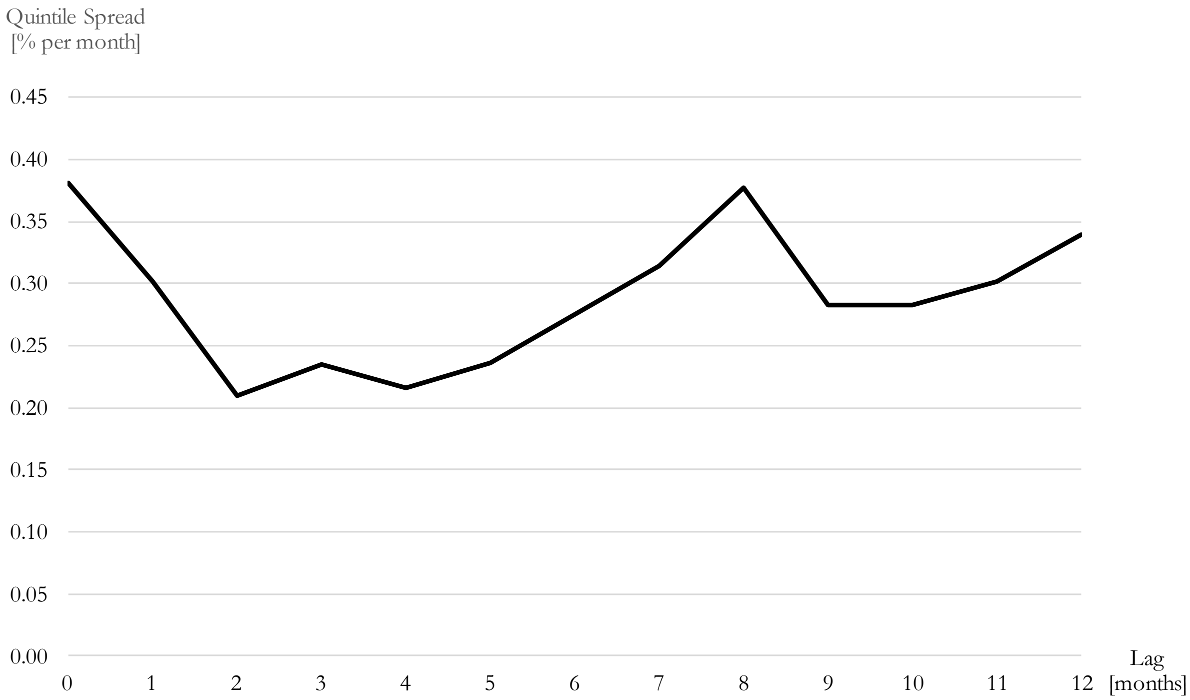


Table 1: Summary Statistics and Strategy Performance

The table reports the total number of panel observations as well as the as well as time-series averages and selected test statistics of excess money demand, currency excess returns, and various other variables in monthly frequency. CV refers to the contemporaneous vintage, while FV refers to final vintage. In particular, the table shows the time-series average ("Mean"), standard deviation, minimum and maximum as well as the average cross-sectional correlation with excess money demand CV. Time-series averages are also reported for observations sorted each month into quintiles from low (Q1) to high (Q5) based on excess money supply CV. The table also shows the time series averages of the quintile spreads as well as the associated *t*-statistics. The sample period is October 2004 to May 2020. All variables are defined in Table A1.

							CV Signal Quintiles					Q5–Q1	
	Observations	Mean	Standard Deviation	Correlation with CV (T)	Minimum	Maximum	Q1 (low)	Q2	Q3	Q4	Q5 (high)	Average	*t-stat*
Excess Money Demand CV (*T*)	2,805	1.51	4.41	1.00	-0.57	16.94	-0.26	0.05	0.22	0.65	6.92	7.18	27.5
Excess Money Demand FV (*T*)	2,805	1.75	4.99	0.91	-0.37	19.40	-0.05	0.05	0.26	0.74	7.77	7.82	23.6
Currency Returns (*T*)	2,805	0.02	2.17	0.07	-4.10	4.14	-0.19	-0.03	-0.02	0.06	0.25	0.44	2.96
Currency Returns (*T*+1)	2,805	0.02	2.19	0.07	-4.12	4.16	-0.14	-0.03	0.05	-0.05	0.25	0.38	2.51
Carry Trade (*T*) * 100	2,805	0.10	0.30	0.34	-0.19	0.92	0.01	0.00	0.02	0.14	0.32	0.31	16.9
1-Month Momentum (*T*) * 100	2,805	-0.05	2.15	0.07	-4.18	3.93	-0.27	-0.08	-0.06	-0.02	0.19	0.46	3.15
3-Months Momentum (*T*) * 100	2,805	-0.10	3.75	0.13	-7.30	6.82	-0.70	-0.05	-0.11	-0.25	0.62	1.31	4.92
12-Months Momentum (*T*) * 100	2,800	-0.05	7.46	0.17	-14.0	13.8	-0.98	-0.28	-0.05	-1.26	2.25	3.22	5.72
Filter Rule Combination (*T*)	2,805	1.06	0.31	0.05	0.54	1.56	1.05	1.08	1.05	1.04	1.07	0.01	0.75
Dollar Exposures (*T*)	2,726	0.60	0.36	-0.04	-0.14	1.20	0.52	0.55	0.65	0.61	0.65	0.12	3.95
Term Spread (*T*) * 100	2,528	0.28	1.28	0.04	-2.09	2.60	0.19	0.28	0.28	0.32	0.29	0.10	0.87
Output Gap (*T*) * 100	2,697	-0.77	6.11	-0.11	-12.8	9.83	-1.19	-0.80	-0.92	-1.29	0.06	1.24	2.96
Currency Value (*T*) * 100	2,805	1.93	14.4	0.10	-28.7	27.5	0.02	1.13	1.22	2.57	4.71	4.69	4.27
Taylor Rule (*T*) * 100	2,697	-0.10	3.16	-0.09	-6.24	5.46	-0.43	-0.20	-0.25	-0.29	0.49	0.91	4.11
Inflation Rate (*T*+1) * 100	2,805	0.21	0.40	0.07	-0.39	1.13	0.16	0.16	0.13	0.28	0.27	0.10	4.17
Growth in M1 (*T*) * 100	2,805	0.76	1.38	-0.09	-1.46	3.88	0.68	0.69	0.59	0.94	0.74	0.06	0.55

Table 2: Panel Regressions with Currency Excess Returns

The table shows coefficients and test statistics from panel regressions of monthly currency excess returns on excess money demand and control variables. Panels A and B use the contemporaneous currency excess return from month t as dependent variable, while Panels C and D use next month's (i.e., $t + 1$) currency excess return as dependent variable. Panels A and C employ the CV version of excess money demand in month t, while Panels B and D use the FV version of excess money demand in month t. Across different specifications, regressions include prior month (i.e., $t - 1$ for Panels A and B and t for Panels C and D) values of the change in M1, the carry trade, 1-month momentum 3-months momentum, 12-months momentum, a filter rule, dollar exposures, term spread, output gap, currency value, the Taylor rule, and the growth in M2. The table employs quintile dummies for excess money demand, i.e. Excess Money Demand Q2 – Q5 with Q1 omitted due to the regression intercept. Each month's quintiles are determined from sorts of currencies with non-missing values for all variables. The bottom of the table shows results using parametric Excess Money Demand for the same specifications and controls as in the top of the table. Control variables are included in their parametric form. All regressions include month fixed effects. Driscoll-Kraay (1998) cross-sectional and time-series dependence robust standard errors are used in calculating the t-statistics. The table also shows the number of observations and the adjusted R-squared. The sample period is October 2004 to May 2020. All variables are defined in Appendix A1.

Panel A: Contemporaneous Excess Returns (t) and CV Signal

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Excess Money Demand Quintile Dummies														
Excess Money Demand CV Q5 (t)	0.446	0.446	0.341	0.454	0.471	0.515	0.445	0.447	0.444	0.446	0.488	0.443	0.436	0.405
	[2.81]	[2.81]	[1.84]	[2.82]	[2.88]	[3.12]	[2.78]	[2.84]	[2.79]	[2.82]	[2.84]	[2.82]	[2.77]	[2.18]
Excess Money Demand CV Q4 (t)	0.164	0.163	0.116	0.166	0.161	0.140	0.158	0.164	0.163	0.163	0.174	0.159	0.155	0.072
	[1.10]	[1.10]	[0.77]	[1.10]	[1.07]	[0.98]	[1.06]	[1.11]	[1.10]	[1.11]	[1.11]	[1.10]	[1.05]	[0.47]
Excess Money Demand CV Q3 (t)	0.101	0.100	0.088	0.103	0.108	0.112	0.098	0.102	0.100	0.101	0.106	0.102	0.096	0.100
	[0.81]	[0.81]	[0.70]	[0.82]	[0.85]	[0.88]	[0.78]	[0.83]	[0.81]	[0.81]	[0.85]	[0.82]	[0.78]	[0.77]
Excess Money Demand CV Q2 (t)	0.068	0.068	0.065	0.071	0.077	0.065	0.069	0.069	0.067	0.067	0.078	0.065	0.068	0.057
	[0.55]	[0.55]	[0.52]	[0.56]	[0.59]	[0.50]	[0.54]	[0.55]	[0.54]	[0.56]	[0.61]	[0.54]	[0.54]	[0.44]
Growth in M1 (t-1)		0.271												-0.329
		[0.12]												[-0.17]
Carry Trade (t-1)			32.99											29.83
			[0.86]											[0.74]
1-Month Momentum (t-1)				-2.164										-0.416
				[-0.58]										[-0.09]
3-Months Momentum (t-1)					-2.078									-1.338
					[-0.88]									[-0.35]
12-Months Momentum (t-1)						-1.976								-2.128
						[-1.58]								[-1.43]
Filter Rule Combination (t-1)							-0.183							0.205
							[-0.86]							[0.56]
Dollar Exposures (t-1)								-0.009						-0.015
								[-0.05]						[-0.07]
Term Spread (t-1)									1.651					2.803
									[0.36]					[0.56]
Output Gap (t-1)										0.138				-4.008
										[0.15]				[-0.95]
Currency Value (t-1)											-0.448			0.146
											[-0.80]			[0.22]
Taylor Rule (t-1)												0.793		8.145
												[0.43]		[0.97]
Growth in M2 (t-1)													4.444	3.665
													[1.21]	[1.05]
Month Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Standard Errors							Driscoll-Kraay							
Adjusted R-Squared	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
Observations	2,579	2,579	2,579	2,579	2,579	2,579	2,579	2,579	2,579	2,579	2,579	2,579	2,579	2,579
Parametric Excess Money Demand														
Excess Money Demand CV (t)	0.032	0.032	0.024	0.032	0.034	0.040	0.032	0.032	0.032	0.034	0.039	0.035	0.032	0.037
	[2.12]	[2.13]	[1.44]	[2.12]	[2.24]	[2.63]	[2.08]	[2.12]	[2.15]	[2.18]	[2.39]	[2.27]	[2.11]	[1.96]
Same Controls and Fixed Effects as above	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-Squared	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59

(continued)

Table 2: Panel Regressions with Currency Excess Returns (continued)

Panel B: Contemporaneous Excess Returns (*t*) and FV Signal

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Excess Money Demand Quintile Dummies														
Excess Money Demand FV Q5 (*t*)	0.314	0.314	0.182	0.321	0.329	0.377	0.309	0.313	0.313	0.313	0.353	0.311	0.309	0.244
	[1.71]	[1.71]	[1.02]	[1.68]	[1.70]	[1.91]	[1.67]	[1.83]	[1.71]	[1.71]	[1.92]	[1.71]	[1.69]	[1.42]
Excess Money Demand FV Q4 (*t*)	0.058	0.058	-0.053	0.058	0.058	0.061	0.053	0.058	0.060	0.058	0.067	0.055	0.045	-0.068
	[0.39]	[0.39]	[-0.36]	[0.39]	[0.38]	[0.40]	[0.35]	[0.41]	[0.41]	[0.39]	[0.44]	[0.38]	[0.31]	[-0.50]
Excess Money Demand FV Q3 (*t*)	0.206	0.207	0.184	0.210	0.209	0.226	0.202	0.205	0.205	0.206	0.215	0.207	0.202	0.207
	[1.68]	[1.68]	[1.52]	[1.66]	[1.65]	[1.75]	[1.64]	[1.82]	[1.68]	[1.67]	[1.71]	[1.69]	[1.65]	[1.67]
Excess Money Demand FV Q2 (*t*)	0.216	0.216	0.212	0.220	0.223	0.230	0.218	0.216	0.216	0.215	0.228	0.213	0.213	0.224
	[1.37]	[1.38]	[1.34]	[1.35]	[1.35]	[1.41]	[1.35]	[1.38]	[1.38]	[1.38]	[1.47]	[1.37]	[1.35]	[1.39]
Growth in M1 (*t*-1)		0.561												-0.224
		[0.24]												[-0.12]
Carry Trade (*t*-1)			52.23											50.52
			[1.49]											[1.33]
1-Month Momentum (*t*-1)				-2.131										-0.727
				[-0.56]										[-0.16]
3-Months Momentum (*t*-1)					-1.885									-1.196
					[-0.78]									[-0.32]
12-Months Momentum (*t*-1)						-1.807								-2.081
						[-1.38]								[-1.38]
Filter Rule Combination (*t*-1)							-0.182							0.200
							[-0.85]							[0.56]
Dollar Exposures (*t*-1)								0.007						-0.01
								[0.04]						[-0.05]
Term Spread (*t*-1)									1.637					3.177
									[0.36]					[0.65]
Output Gap (*t*-1)										0.136				-4.007
										[0.15]				[-0.95]
Currency Value (*t*-1)											-0.372			0.17
											[-0.67]			[0.27]
Taylor Rule (*t*-1)												0.902		8.223
												[0.48]		[0.97]
Growth in M2 (*t*-1)													5.094	3.661
													[1.40]	[1.04]
Month Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Standard Errors							Driscoll-Kraay							
Adjusted R-Squared	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.59
Observations	2,579	2,579	2,579	2,579	2,579	2,579	2,579	2,579	2,579	2,579	2,579	2,579	2,579	2,579
Parametric Excess Money Demand														
Excess Money Demand FV (*t*)	0.016	0.016	0.009	0.016	0.017	0.022	0.016	0.016	0.016	0.018	0.020	0.019	0.016	0.017
	[0.94]	[0.94]	[0.52]	[0.94]	[0.99]	[1.22]	[0.92]	[0.93]	[0.95]	[0.98]	[1.08]	[1.04]	[0.92]	[0.80]
Same Controls and Fixed Effects as above	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-Squared	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.59

(continued)

Table 2: Panel Regressions with Currency Excess Returns (continued)

Panel C: Next Month's Excess Returns (*t*+1) and CV Signal

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Excess Money Demand Quintile Dummies														
Excess Money Demand CV Q5 (*t*)	0.418	0.417	0.299	0.427	0.449	0.499	0.419	0.422	0.416	0.418	0.466	0.416	0.408	0.375
	[2.22]	[2.22]	[1.45]	[2.25]	[2.38]	[2.58]	[2.19]	[2.28]	[2.19]	[2.23]	[2.34]	[2.23]	[2.17]	[1.88]
Excess Money Demand CV Q4 (*t*)	0.078	0.077	0.023	0.082	0.083	0.057	0.074	0.081	0.078	0.077	0.090	0.073	0.071	-0.017
	[0.58]	[0.57]	[0.17]	[0.60]	[0.60]	[0.42]	[0.54]	[0.61]	[0.57]	[0.58]	[0.63]	[0.56]	[0.53]	[-0.13]
Excess Money Demand CV Q3 (*t*)	0.133	0.132	0.119	0.135	0.141	0.146	0.129	0.135	0.131	0.134	0.140	0.135	0.130	0.137
	[1.10]	[1.09]	[0.97]	[1.11]	[1.15]	[1.16]	[1.05]	[1.16]	[1.08]	[1.08]	[1.13]	[1.10]	[1.07]	[1.13]
Excess Money Demand CV Q2 (*t*)	0.060	0.060	0.056	0.062	0.069	0.057	0.061	0.061	0.059	0.059	0.071	0.057	0.058	0.051
	[0.46]	[0.45]	[0.43]	[0.47]	[0.51]	[0.42]	[0.45]	[0.47]	[0.44]	[0.46]	[0.53]	[0.45]	[0.44]	[0.39]
Growth in M1 (*t*)		0.391												-0.292
		[0.17]												[-0.16]
Carry Trade (*t*)			38.40											34.24
			[1.03]											[0.87]
1-Month Momentum (*t*)				-2.022										0.45
				[-0.55]										[0.10]
3-Months Momentum (*t*)					-2.479									-1.752
					[-1.06]									[-0.47]
12-Months Momentum (*t*)						-2.186								-2.255
						[-1.72]								[-1.51]
Filter Rule Combination (*t*)							-0.229							0.180
							[-1.07]							[0.51]
Dollar Exposures (*t*)								-0.022						-0.03
								[-0.11]						[-0.15]
Term Spread (*t*)									1.562					2.814
									[0.34]					[0.56]
Output Gap (*t*)										0.15				-4.354
										[0.16]				[-1.03]
Currency Value (*t*)											-0.492			0.155
											[-0.88]			[0.23]
Taylor Rule (*t*)												0.879		8.946
												[0.47]		[1.06]
Growth in M2 (*t*)													4.858	4.02
													[1.34]	[1.17]
Month Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Standard Errors							Driscoll-Kraay							
Adjusted R-Squared	0.58	0.58	0.58	0.58	0.58	0.59	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.59
Observations	2,579	2,579	2,579	2,579	2,579	2,579	2,579	2,579	2,579	2,579	2,579	2,579	2,579	2,579
Parametric Excess Money Demand														
Excess Money Demand CV (*t*)	0.036	0.036	0.029	0.037	0.038	0.046	0.036	0.036	0.036	0.039	0.045	0.040	0.036	0.043
	[2.42]	[2.43]	[1.69]	[2.42]	[2.56]	[3.01]	[2.35]	[2.43]	[2.46]	[2.47]	[2.84]	[2.57]	[2.41]	[2.28]
Same Controls and Fixed Effects as above	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-Squared	0.58	0.58	0.58	0.58	0.58	0.59	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.59

(continued)

Table 2: Panel Regressions with Currency Excess Returns (continued)

Panel D: Next Month's Excess Returns (*t*+1) and FV Signal

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Excess Money Demand Quintile Dummies														
Excess Money Demand FV Q5 (*t*)	0.220	0.220	0.082	0.225	0.240	0.284	0.214	0.219	0.219	0.220	0.261	0.218	0.209	0.137
	[1.22]	[1.23]	[0.44]	[1.23]	[1.29]	[1.51]	[1.18]	[1.30]	[1.22]	[1.22]	[1.45]	[1.22]	[1.16]	[0.79]
Excess Money Demand FV Q4 (*t*)	0.005	0.005	-0.110	0.006	0.006	0.009	0.001	0.005	0.007	0.005	0.014	0.002	-0.012	-0.131
	[0.03]	[0.03]	[-0.65]	[0.04]	[0.04]	[0.05]	[0.00]	[0.03]	[0.05]	[0.03]	[0.09]	[0.01]	[-0.07]	[-0.83]
Excess Money Demand FV Q3 (*t*)	0.069	0.070	0.046	0.072	0.078	0.091	0.066	0.068	0.068	0.070	0.079	0.070	0.063	0.066
	[0.58]	[0.59]	[0.39]	[0.60]	[0.65]	[0.73]	[0.55]	[0.62]	[0.57]	[0.58]	[0.65]	[0.59]	[0.53]	[0.58]
Excess Money Demand FV Q2 (*t*)	0.130	0.131	0.125	0.134	0.142	0.148	0.135	0.130	0.131	0.130	0.144	0.128	0.124	0.137
	[1.03]	[1.03]	[1.00]	[1.03]	[1.08]	[1.13]	[1.02]	[1.04]	[1.03]	[1.02]	[1.14]	[1.01]	[0.96]	[1.07]
Growth in M1 (*t*)		0.483												-0.408
		[0.21]												[-0.22]
Carry Trade (*t*)			54.72											52.87
			[1.53]											[1.37]
1-Month Momentum (*t*)				-1.769										0.474
				[-0.47]										[0.10]
3-Months Momentum (*t*)					-2.242									-1.745
					[-0.93]									[-0.46]
12-Months Momentum (*t*)						-1.887								-2.06
						[-1.43]								[-1.36]
Filter Rule Combination (*t*)							-0.224							0.161
							[-1.04]							[0.45]
Dollar Exposures (*t*)								0.007						-0.009
								[0.04]						[-0.04]
Term Spread (*t*)									1.658					3.2
									[0.37]					[0.65]
Output Gap (*t*)										0.102				-4.015
										[0.11]				[-0.95]
Currency Value (*t*)											-0.383			0.174
											[-0.69]			[0.27]
Taylor Rule (*t*)												0.857		8.256
												[0.46]		[0.98]
Growth in M2 (*t*)													5.323	4.061
													[1.46]	[1.16]
Month Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Standard Errors							Driscoll-Kraay							
Adjusted R-Squared	0.58	0.58	0.59	0.58	0.59	0.59	0.59	0.58	0.58	0.58	0.58	0.58	0.59	0.59
Observations	2,579	2,579	2,579	2,579	2,579	2,579	2,579	2,579	2,579	2,579	2,579	2,579	2,579	2,579
Parametric Excess Money Demand														
Excess Money Demand FV (*t*)	0.027	0.027	0.021	0.027	0.028	0.034	0.027	0.027	0.027	0.029	0.033	0.030	0.027	0.031
	[1.87]	[1.88]	[1.32]	[1.86]	[1.91]	[2.23]	[1.80]	[1.88]	[1.91]	[1.91]	[2.19]	[2.00]	[1.85]	[1.68]
Same Controls and Fixed Effects as above	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-Squared	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.59

Table 3: Factor Model Time-Series Regressions

The table shows intercepts, slope coefficients, and *t*-statistics from time series regressions of monthly portfolio currency excess returns on alternative sets of risk factors. Currencies are sorted each month into quintiles based on excess money demand and combined into equally weighted portfolios. Panels A and C employ the CV version of excess money demand, while Panels B and D use the FV version of excess money demand. In Panels A and B, the signal is contemporaneous with the currency excess return, while it is from the prior month in Panels C and D. The table reports averages and regression statistics separately for each of the five portfolios, Q1–Q5, and for the corresponding times series of return spreads between the most undersupplied (Q5) and oversupplied (Q1) currency quintiles. The table shows results for alternative factor models. Risk factors are alternatively the dollar risk factor and the carry trade risk factors from Lustig, Roussanov, and Verdelhan (2011), the global imbalance factor (Della Corte, Riddiough, and Sarno, 2016), an output gap factor (Colacito et al., 2020), and a sovereign risk factor (Della Corte et al., 2021), the UMVE factor from Chernov, Dahlquist, and Lochstoer (2022), and a combination of all six factors. Heteroscedastic-robust standard errors are used in calculating the *t*-statistics. The table also shows the number of observations and R-squared. The sample period is October 2004 to May 2020. All variables are defined in Appendix A1.

Panel A: Contemporaneous Excess Returns (*t*) and CV Signal

	CV Signal										Q5-Q1 (high - low)	
	Q1 (low)		Q2		Q3		Q4		Q5 (high)			
	Coef	*t*-stat	Coef	*t*-stat	Coef	*t*-stat	Coef	*t*-stat	Coef	*t*-stat	Coef	*t*-stat
LRV 2-Factor Model												
Intercept	-0.187	[–1.40]	-0.042	[–0.45]	-0.025	[–0.24]	0.039	[0.34]	0.165	[1.35]	0.352	[2.30]
Dollar Factor	1.265	[13.5]	1.202	[17.5]	1.474	[17.3]	1.396	[16.4]	1.273	[15.3]	0.008	[0.09]
Carry Factor	-0.142	[–1.49]	-0.100	[–2.55]	-0.139	[–2.58]	-0.075	[–1.20]	0.146	[2.09]	0.287	[2.98]
R-Squared	0.64		0.74		0.77		0.73		0.70		0.11	
Observations	187		187		187		187		187		187	
Global Imbalance Factor												
Intercept	-0.176	[–0.89]	-0.020	[–0.11]	-0.002	[–0.01]	0.081	[0.40]	0.274	[1.35]	0.450	[3.17]
Output Gap Factor												
Intercept	-0.189	[–0.94]	-0.038	[–0.21]	-0.019	[–0.09]	0.058	[0.27]	0.242	[1.12]	0.431	[2.94]
Sovereign Risk Factor												
Intercept	-0.155	[–0.76]	0.026	[0.15]	0.051	[0.24]	0.089	[0.41]	0.274	[1.26]	0.428	[2.82]
CDL UMVE Currency Factor												
Intercept	-0.189	[–0.94]	-0.040	[–0.22]	-0.019	[–0.09]	0.076	[0.36]	0.248	[1.15]	0.437	[2.97]
6-Factor Combination Model												
Intercept	-0.205	[–1.59]	-0.064	[–0.72]	-0.017	[–0.17]	0.048	[0.44]	0.167	[1.39]	0.372	[2.46]

(continued)

Table 3: Factor Model Time-Series Regressions (continued)

Panel B: Contemporaneous Excess Returns (*t*) and FV Signal

	FV Signal										Q5-Q1 (high - low)	
	Q1 (low)		Q2		Q3		Q4		Q5 (high)			
	Coef	*t*-stat	Coef	*t*-stat	Coef	*t*-stat	Coef	*t*-stat	Coef	*t*-stat	Coef	*t*-stat
LRV 2-Factor Model												
Intercept	-0.112	[–1.04]	0.100	[0.98]	0.069	[0.66]	-0.145	[–1.37]	0.037	[0.25]	0.150	[0.82]
Dollar Factor	1.051	[16.3]	1.294	[17.1]	1.469	[18.0]	1.358	[20.0]	1.439	[11.9]	0.388	[2.59]
Carry Factor	-0.156	[–2.37]	-0.148	[–3.12]	-0.197	[–3.55]	0.037	[0.70]	0.155	[1.49]	0.310	[2.27]
R-Squared	0.62		0.73		0.76		0.77		0.69		0.21	
Observations	187		187		187		187		187		187	
Global Imbalance Factor												
Intercept	-0.119	[–0.71]	0.112	[0.60]	0.070	[0.33]	-0.067	[–0.34]	0.161	[0.71]	0.280	[1.66]
Output Gap Factor												
Intercept	-0.118	[–0.70]	0.089	[0.47]	0.056	[0.26]	-0.090	[–0.43]	0.118	[0.49]	0.236	[1.32]
Sovereign Risk Factor												
Intercept	-0.098	[–0.56]	0.166	[0.90]	0.120	[0.57]	-0.060	[–0.28]	0.157	[0.64]	0.254	[1.37]
CDL UMVE Currency Factor												
Intercept	-0.115	[–0.69]	0.087	[0.45]	0.065	[0.30]	-0.087	[–0.41]	0.125	[0.51]	0.240	[1.32]
6-Factor Combination Model												
Intercept	-0.127	[–1.23]	0.084	[0.88]	0.056	[0.56]	-0.132	[–1.27]	0.049	[0.36]	0.176	[1.11]

(continued)

Table 3: Factor Model Time-Series Regressions (continued)

Panel C: Next Month's Excess Returns (*t*+1) and CV Signal

	CV Signal										Q5-Q1 (high - low)	
	Q1 (low)		Q2		Q3		Q4		Q5 (high)			
	Coef	*t*-stat	Coef	*t*-stat	Coef	*t*-stat	Coef	*t*-stat	Coef	*t*-stat	Coef	*t*-stat
LRV 2-Factor Model												
Intercept	-0.107	[–0.81]	-0.013	[–0.13]	0.057	[0.52]	-0.086	[–0.73]	0.179	[1.39]	0.287	[1.91]
Dollar Factor	1.257	[11.4]	1.265	[17.9]	1.365	[13.6]	1.443	[17.3]	1.295	[15.2]	0.038	[0.36]
Carry Factor	-0.191	[–2.02]	-0.145	[–3.47]	-0.115	[–1.68]	0.027	[0.40]	0.137	[1.90]	0.328	[3.74]
R-Squared	0.64		0.75		0.75		0.75		0.69		0.14	
Observations	187		187		187		187		187		187	
Global Imbalance Factor												
Intercept	-0.124	[–0.65]	-0.019	[–0.10]	0.066	[0.33]	-0.032	[–0.14]	0.269	[1.29]	0.393	[2.62]
Output Gap Factor												
Intercept	-0.137	[–0.69]	-0.033	[–0.18]	0.050	[0.25]	-0.053	[–0.23]	0.245	[1.10]	0.382	[2.50]
Sovereign Risk Factor												
Intercept	-0.097	[–0.50]	0.038	[0.21]	0.120	[0.59]	-0.043	[–0.18]	0.276	[1.24]	0.373	[2.47]
CDL UMVE Currency Factor												
Intercept	-0.146	[–0.74]	-0.031	[–0.16]	0.061	[0.30]	-0.043	[–0.19]	0.245	[1.11]	0.391	[2.58]
6-Factor Combination Model												
Intercept	-0.106	[–0.88]	-0.029	[–0.31]	0.079	[0.79]	-0.119	[–1.07]	0.194	[1.52]	0.300	[2.06]

(continued)

Table 3: Factor Model Time-Series Regressions (continued)

Panel D: Next Month's Excess Returns (t+1) and FV Signal

	FV Signal										Q5-Q1 (high - low)	
	Q1 (low)		Q2		Q3		Q4		Q5 (high)			
	Coef	*t*-stat	Coef	*t*-stat	Coef	*t*-stat	Coef	*t*-stat	Coef	*t*-stat	Coef	*t*-stat
LRV 2-Factor Model												
Intercept	-0.124	[–1.04]	0.095	[1.01]	0.044	[0.44]	-0.083	[–0.72]	0.098	[0.70]	0.222	[1.29]
Dollar Factor	1.037	[14.2]	1.246	[19.0]	1.546	[20.6]	1.347	[19.1]	1.449	[12.3]	0.413	[2.77]
Carry Factor	-0.090	[–1.19]	-0.179	[–3.92]	-0.151	[–2.96]	0.014	[0.22]	0.119	[1.28]	0.209	[1.69]
R-Squared	0.58		0.75		0.81		0.73		0.71		0.18	
Observations	187		187		187		187		187		187	
Global Imbalance Factor												
Intercept	-0.119	[–0.69]	0.079	[0.44]	0.046	[0.22]	-0.036	[–0.17]	0.189	[0.85]	0.308	[1.84]
Output Gap Factor												
Intercept	-0.127	[–0.72]	0.066	[0.36]	0.029	[0.13]	-0.050	[–0.24]	0.154	[0.65]	0.281	[1.61]
Sovereign Risk Factor												
Intercept	-0.089	[–0.52]	0.135	[0.77]	0.094	[0.43]	-0.033	[–0.15]	0.187	[0.78]	0.276	[1.60]
CDL UMVE Currency Factor												
Intercept	-0.120	[–0.69]	0.063	[0.34]	0.033	[0.15]	-0.046	[–0.21]	0.157	[0.65]	0.277	[1.58]
6-Factor Combination Model												
Intercept	-0.108	[–1.01]	0.092	[1.01]	0.038	[0.39]	-0.104	[–0.92]	0.103	[0.79]	0.212	[1.40]

Table 4: Excess Money Demand vs. Carry

The table shows results from panel regressions (Panel A) and factor model time-series regressions (Panel B) using excess money demand CV and carry characteristics and factors. Panel A shows coefficients and test statistics from panel regressions of monthly next month's (i.e., $t + 1$) currency excess return on excess money demand CV, carry, and control variables. Specifications (1) and (2) use non-parametric versions of excess money demand CV and carry employing quintile dummies Q2 – Q5 with Q1 omitted due to the regression intercept. Each month's quintiles are determined from sorts of currencies with non-missing values for all variables. In contrast, specifications (3) and (4) use their parametric form. All specifications include month fixed effects. Specifications (3) and (4) also include the following parametric controls: the change in M1, 1-month momentum 3-months momentum, 12-months momentum, a filter rule, dollar exposures, term spread, output gap, currency value, the Taylor rule, and the growth in M2. Driscoll-Kraay (1998) cross-sectional and time-series dependence robust standard errors are used in calculating the t-statistics. The table also shows the number of observations and the adjusted R-squared. Panel B shows intercepts, slope coefficients, and t-statistics from time series regressions of monthly portfolio currency excess returns on alternative sets of risk factors. Currencies are sorted each month into quintiles based on alternatively, excess money demand CV and carry, and combined into equally weighted portfolios. The panel reports averages and regression statistics separately for each of the five portfolios, Q1–Q5, and for the corresponding times series of return spreads between the fifth and first quintile portfolio. The table shows results for alternative factor models. The dollar risk factor and the carry trade risk factors are constructed following Lustig, Roussanov, and Verdelhan; 2011). The CV factor is the spread between the fifth and first portfolio of equal weighted currencies sorted by the CV signal in the prior month. All factors are based on the 15 currencies in the sample. Heteroscedastic-robust standard errors are used in calculating the t-statistics. The table also shows the number of observations and R-squared. The sample period is October 2004 to May 2020. All variables are defined in Appendix A1.

Panel A: Panel Regressions

	(1)	(2)	(3)	(4)
Excess Money Demand CV Q5 (t)	0.357	0.409		
	[1.85]	[2.24]		
Excess Money Demand CV Q4 (t)	0.057	-0.003		
	[0.43]	[-0.02]		
Excess Money Demand CV Q3 (t)	0.129	0.142		
	[1.06]	[1.17]		
Excess Money Demand CV Q2 (t)	0.051	0.039		
	[0.40]	[0.30]		
Carry Q5 (t)	0.044	0.006		
	[0.20]	[0.03]		
Carry Q4 (t)	0.047	0.055		
	[0.24]	[0.28]		
Carry Q3 (t)	-0.043	-0.059		
	[-0.29]	[-0.40]		
Carry Q2 (t)	-0.084	-0.134		
	[-0.64]	[-1.05]		
Excess Money Demand CV (t)			0.029	0.043
			[1.69]	[2.28]
Carry (t)			41.99	38.25
			[1.17]	[1.00]
Controls for all other variables	No	Yes	No	Yes
Month Fixed Effects	Yes	Yes	Yes	Yes
Standard Errors	Driscoll-Kraay		Driscoll-Kraay	
Adjusted R-Squared	0.58	0.59	0.58	0.59
Observations	2,579	2,579	2,579	2,579

(continued)

Table 4: Excess Money Demand vs. Carry (continued)

Panel B: Factor Model Regressions

	Signal										Q5-Q1	
	Q1 (low)		Q2		Q3		Q4		Q5 (high)		(high - low)	
	Coef	*t*-stat	Coef	*t*-stat	Coef	*t*-stat	Coef	*t*-stat	Coef	*t*-stat	Coef	*t*-stat
Excess Money Demand CV Portfolios												
Intercept	-0.143	[–1.31]	-0.017	[–0.22]	0.063	[0.80]	-0.076	[–0.83]	0.173	[1.95]	0.316	[2.11]
Dollar Factor	0.922	[12.23]	0.943	[25.16]	1.036	[16.97]	1.103	[25.67]	0.996	[28.78]	0.074	[0.90]
Carry Factor	-0.041	[–0.64]	-0.114	[–4.14]	-0.119	[–3.45]	0.039	[0.78]	0.234	[4.71]	0.275	[2.93]
R-Squared	73%		84%		85%		85%		86%		17%	
Observations	187		187		187		187		187		187	
Intercept	-0.189	[–0.94]	-0.063	[–0.34]	0.012	[0.06]	-0.131	[–0.60]	0.123	[0.62]	0.312	[2.08]
Carry Factor	0.210	[1.80]	0.142	[1.74]	0.161	[2.24]	0.338	[3.78]	0.505	[7.27]	0.295	[2.99]
R-Squared	5%		2%		3%		9%		22%		16%	
Observations	187		187		187		187		187		187	
Carry Portfolios												
Intercept	0.022	[0.25]	-0.098	[–1.09]	-0.056	[–0.71]	0.050	[0.62]	0.082	[0.66]	0.060	[0.35]
Dollar Factor	0.802	[11.94]	0.942	[16.21]	1.027	[28.55]	1.175	[30.86]	1.054	[11.81]	0.251	[1.84]
CV Factor	-0.223	[–3.37]	-0.129	[–1.97]	0.001	[0.03]	0.099	[2.21]	0.252	[2.47]	0.474	[3.20]
R-Squared	73%		82%		86%		89%		74%		21%	
Observations	187		187		187		187		187		187	
Intercept	-0.040	[–0.22]	-0.171	[–0.88]	-0.135	[–0.65]	-0.037	[–0.16]	-0.003	[–0.01]	0.038	[0.21]
CV Factor	-0.025	[–0.24]	0.103	[0.98]	0.254	[1.78]	0.388	[2.44]	0.511	[2.95]	0.536	[3.92]
R-Squared	0%		1%		4%		6%		10%		16%	
Observations	187		187		187		187		187		187	

Table 5: Panel Regressions with Inflation Rate (*t*+1)

The table shows coefficients and test statistics from panel regressions of the monthly inflation rate on excess money demand and control variables. Panel A uses the CV signal, while Panel B uses the FV signal. Across different specifications, inflation in month $t + 1$ is regressed against prior month values of excess money demand, the inflation rate, the growth rate in M1, the currency excess return in month $t + 1$, and the predicted inflation rate in month $t + 1$ (from specification (1)). The table employs quintile dummies for excess money demand, i.e. excess money demand Q2 – Q5 with Q1 omitted due to the regression intercept. Each month's quintiles are determined from sorts of currencies with non-missing values for all variables. The bottom of the table shows results using parametric Excess Money Demand (as well as the predicted expected inflation rate) for the same specifications and controls as in the top of the table. All coefficients are multiplied by 100. All regressions include month fixed effects. Driscoll-Kraay cross-sectional and time-series dependence robust standard errors are used in calculating the *t*-statistics. The table also shows the number of observations and the adjusted R-squared. The sample period is October 2004 to May 2020. All variables are defined in Appendix A1.

Panel A: CV Signal

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Excess Money Demand Quintile Dummies								
Excess Money Demand CV Q5 (*t*)	0.090	0.064	0.063	0.063				
	[2.82]	[2.17]	[2.16]	[2.13]				
Excess Money Demand CV Q4 (*t*)	0.112	0.082	0.080	0.080				
	[2.62]	[2.16]	[2.11]	[2.11]				
Excess Money Demand CV Q3 (*t*)	-0.038	-0.038	-0.038	-0.038				
	[-1.28]	[-1.50]	[-1.50]	[-1.51]				
Excess Money Demand CV Q2 (*t*)	-0.003	-0.003	-0.003	-0.003				
	[-0.09]	[-0.11]	[-0.12]	[-0.12]				
Inflation Rate (*t*)		0.226	0.224	0.223		0.228	0.225	0.225
		[5.38]	[5.37]	[5.39]		[5.50]	[5.49]	[5.52]
Growth Rate in M1 (*t*)			0.007	0.007			0.008	0.008
			[1.10]	[1.10]			[1.16]	[1.16]
Currency Return (*t*+1)				0.001				0.001
				[0.14]				[0.09]
Expected Inflation Rate (*t*+1)					0.687	0.484	0.476	0.476
					[6.13]	[4.66]	[4.65]	[4.58]
Month Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Standard Errors				Driscoll-Kraay				
Adjusted R-Squared	0.20	0.24	0.24	0.24	0.20	0.24	0.24	0.24
Observations	2,685	2,685	2,685	2,685	2,685	2,685	2,685	2,685
Parametric Excess Money Demand								
Excess Money Demand CV (*t*)	0.006	0.006	0.005	0.005				
	[3.02]	[3.16]	[2.82]	[2.83]				
Expected Inflation Rate (*t*+1)					0.786	0.572	0.599	0.598
					[3.16]	[2.66]	[2.80]	[2.79]
Same Controls and Fixed Effects as above	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-Squared	0.19	0.19	0.24	0.24	0.19	0.24	0.24	0.24

(continued)

Table 5: Panel Regressions with Inflation Rate (t+1) (continued)

Panel B: FV Signal

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Excess Money Demand Quintile Dummies								
Excess Money Demand FV Q5 (t)	0.144	0.117	0.119	0.119				
	[3.96]	[3.63]	[3.70]	[3.64]				
Excess Money Demand FV Q4 (t)	0.136	0.107	0.109	0.109				
	[3.64]	[3.31]	[3.38]	[3.39]				
Excess Money Demand FV Q3 (t)	-0.016	-0.013	-0.011	-0.011				
	[-0.69]	[-0.60]	[-0.51]	[-0.51]				
Excess Money Demand FV Q2 (t)	-0.007	-0.006	-0.004	-0.004				
	[-0.27]	[-0.28]	[-0.20]	[-0.20]				
Inflation Rate (t)		0.219	0.216	0.215		0.219	0.215	0.215
		[5.13]	[5.10]	[5.16]		[5.11]	[5.08]	[5.12]
Growth in M1 (t)			0.009	0.009			0.009	0.009
			[1.30]	[1.30]			[1.33]	[1.33]
Currency Return (t+1)				0.001				0.000
				[0.15]				[0.07]
Expected Inflation Rate (t+1)					0.659	0.513	0.519	0.518
					[6.08]	[5.32]	[5.36]	[5.30]
Month Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Standard Errors				Driscoll-Kraay				
Adjusted R-Squared	0.21	0.25	0.25	0.25	0.21	0.25	0.25	0.25
Observations	2,685	2,685	2,685	2,685	2,685	2,685	2,685	2,685
Parametric Excess Money Demand								
Excess Money Demand FV (t)	0.007	0.007	0.005	0.005				
	[3.95]	[4.10]	[3.74]	[3.69]				
Expected Inflation Rate (t+1)					0.747	0.543	0.566	0.566
					[3.88]	[3.48]	[3.59]	[3.52]
Same Controls and Fixed Effects as above	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-Squared	0.19	0.20	0.24	0.24	0.20	0.24	0.24	0.24

Appendix A: Closed-Form Solution of Exchange Rate

Letting q_t denote the quotient $(M^*\text{–}a)/(M\text{–}a)$, the unlogged Equation (15) states

$$f = q\frac{d - b\left(\frac{f}{V} - 1\right)}{d^* + b\left(\frac{f}{V} - 1\right)}$$

$$\Leftrightarrow (d^* - b)f + \frac{b}{V}f^2 = qd - \frac{qdb}{V}f + qb$$

$$\Leftrightarrow \frac{b}{V}f^2 + (d^* - b + \frac{qdb}{V})f - q(d + b) = 0.$$

This quadratic equation has a unique positive root for the exchange rate:

$$f = \frac{-(d^* - b + \frac{qdb}{V}) + \sqrt{\left(d^* - b + \frac{qdb}{V}\right)^2 + 4\frac{qb}{V}(d + b)}}{2\frac{b}{V}}.$$

Table A1: Variable Definitions

The table reports the names and definitions of all variables.

Variable	Definition
Panel A: Country/Currency Characteristics	
1–Month Momentum (t)	Currency return (in percent per month) from month t–1 to t, where the currency return is the log difference between the one-month forward exchange rate of month t–1 and the spot exchange rate of month t (see e.g. Menkhoff et al., 2012). Data are from Datastream.
3–Months Momentum (t)	Cumulative currency return (in percent per month) from month t–3 to t, , where the currency return is the log difference between the one-month forward exchange rate of month t–1 and the spot exchange rate of month t (see e.g. Menkhoff et al., 2012). Data are from Datastream.
12–Months Momentum (t)	Cumulative currency return (in percent per month) from month t–12 to t, where the currency return is the log difference between the one-month forward exchange rate of month t–1 and the spot exchange rate of month t (see e.g. Asness et al., 2013). Data are from Datastream.
Carry Trade (t)	Difference between one-month forward exchange rate in month t and spot exchange rate in month t, divided by the spot exchange rate in month t. Variable is in percent per month. Data are from Datastream.
Currency Return (t)	Difference between one-month forward exchange rate in month t–1 and spot exchange rate of month t, divided by the one–month forward exchange rate in month t–1 (see e.g., Lustig, Roussanov, and Verdelhan, 2014). Variable is in percent per month. Data are from Datastream.
Currency Value (t)	At the end of each month t, we calculate each currency's real exchange rate return (RER) over the prior five years. The log RER is given by qt = –st + pkt – pt where s denotes the exchange rate (in foreign currency units per USD), pk denotes the price level in country k, and p denotes the U.S. price level. All variables are in logs. Following Asness et al. (2013), we calculate the lagged five–year (5y) real exchange rate return as Δ(5y)qt = qt – qt – 5y = –Δ(5y) st + π(5y),k – π(5y) (e.g. Menkhoff et al., 2016). Real time data on Consumer Price Indices (CPI) to calculate real exchange rates are from OECD's Original Release Data and Revisions Database.
Dollar Exposures (t)	At the end of each month t, for each currency, the change in the exchange rate is regressed on a constant, the interest rate differential with the United States, the carry factor, the interaction between interest rate differential and carry factor, and the dollar factor using a 60–month rolling window. The carry factor is the average change in exchange rates between high interest rate countries and low interest rate countries based on quintiles. The dollar factor is the average change in exchange rates across all currencies. Dollar Exposure is the estimated beta on the dollar factor from this rolling regression.
Excess Money Demand (t)	Negative scaled residual from regressing narrow money (M1) on prior periods' GDP, exports, and imports using panel data. Alternatively using CV or FV method. In CV method, traders can not observe the most recent two months M1, and use an AR(2) model to get estimates.
Expected Inflation (t+1)	Expected percentage change in consumer price index from month t−1 to t
Exports of goods and services (t)	Exports of goods and services in constant prices and in local currency in month t
Filter Rule Combination (t)	At the end of each month t, currencies are ranked from low to high based on each of the 354 moving average rules, which calculate the difference between short–run (SR) and long–run (LR) moving averages of currency returns, where SR ranges from 1–12 months and LR ranges from 2–36 months. The Filter Rule Combination is the overall sum of ranks for each currency of all these 354 strategies (e.g. Okunev and White, 2003). Variable is deflated by 1,000.
Growth in M1 (t)	Difference in M1 between month t and month t–1, divided by M1 in month t–1
Growth in M2 (t)	Difference in M2 between month t and month t–1, divided by M2 in month t–1
Imports of goods and services (t)	Imports of goods and services in constant prices and in local currency in month t
Inflation Rate (t)	Percentage change in consumer price index from month t−1 to t
Narrow Money M1 (t)	Narrow money (monetary aggregates) in local currency in month t
Output Gap (t)	At the end of each month t, each country's output gap is calculated from detrending the monthly industrial production index (IPI) for each country. Specifically, the residuals from a regression of IPIt on a constant and IPIt–13, IPIt–14, ..., IPIt–24 (corresponding to p=12 and h=24 in Hamilton (2018)) are a measure of detrended output gap (e.g. Colacito, Riddiough and Sarno, 2020). Real time data on industrial production are from OECD's Original Release Data and Revisions Database.
Predicted Change in M1 (t+1)	Predicted value for M1 from panel regression in Table 4 for month t+1
Taylor Rule (t)	At the end of each month t, we calculate the Taylor Rule as 1.5 times inflation and 0.5 times the output gap, which is calculated following the procedure in the Output Gap variable. Real time data on CPI to calculate inflation and real time data on industrial production are from OECD's Original Release Data and Revisions Database.
Term Spread (t)	At the end of each month t, we calculate the difference between a country's long–term interest rates and short–term interest rates (e.g. Ang and Chen, 2010). Short–term rates are three months interest rates (interbank or Treasury bills) and long–term rates are ten year (or if unavailable five year) Government bond rates sourced from Datastream.
Total GDP (t)	Total GDP in current prices and in local currency in month t

(continued)

Table A1: Variable Definitions (continued)

Variable	Definition
Panel B: Currency Factors	
Carry Factor (t)	At the end of each month t, currencies are sorted into five quintiles (Q1 to Q5) from low to high based on forward discounts relative to the U.S. Dollar and combined into equally weighted portfolios. The Carry Factor goes long portfolio Q5 and short Q1 (e.g. Lustig et al., 2011).
CV Factor (t)	At the end of each month t, currencies are sorted into five quintiles (Q1 to Q5) from low to high based on excess money demand CV and combined into equally weighted portfolios. The CV factor goes long portfolio Q5 and short Q1.
Dollar Factor (t)	At the end of each month t, currencies are sorted into five quintiles (Q1 to Q5) from low to high based on forward discounts relative to the U.S. Dollar and combined into equally weighted portfolios. The Dollar Risk Factor is the average of these portfolio returns (e.g. Lustig et al., 2011).
Global Imbalance Factor (t)	At the end of each month t, currencies are sorted into six portfolios using sequential sorts based on net foreign asset position and external liabilities in domestic currency and combined into equally weighted portfolios. The Global Imbalance Factor is the return difference between portfolio 5 and portfolio 1 (Della Corte et al. (2016)).
Output Gap Factor (t)	At the end of each month t, currencies are sorted into quintiles (Q1 to Q5) from low to high based on the output gap and combined into equally weighted portfolios. The output gap is calculated from detrending the monthly industrial production index (IPI) for each country. Specifically, the residuals from a regression of IPIt on a constant and IPIt–13, IPIt–14, ..., IPIt–24 (corresponding to p=12 and h=24 in Hamilton (2018)) are a measure of detrended output gap. The procedure is implemented recursively conditioning on data available at the time of sorting. The Output Gap Factor goes long portfolio Q5 and short Q1 (e.g. Colacito, Riddiough and Sarno, 2020). Real time data on industrial production are from OECD's Original Release Data and Revisions Database.
Sovereign Risk Factor (t)	At the end of each month t–1, currencies are sorted into terciles from low to high based on the lagged CDS spread and combined into equally weighted portfolios. CDS spreads are obtained from USD-denominated CDS contracts written on foreign debts with a tenor of five years (Della Corte, Sarno, Schemling and Wagner (2022)). The Sovereign Risk Factor is the return difference between portfolio 3 and portfolio 1. Data on CDS contracts are from Markit.
UMVE Currency Factor (t)	Return in month t from the unconditional mean–variance efficient (UMVE) portfolio of currencies (e.g. Chernov, Dalquist, and Lochstoer, 2023).

(continued)

Table A2: Summary Statistics

The table reports summary statistics of all variables. The sample period is October 2004 to May 2020. All variables are defined in Table A1.

		Standard				Percentiles							
	Mean	Deviation	Skewness	Kurtosis	Minimum	1st	5th	25th	Median	75th	95th	99th	Maximum
Excess Money Demand CV (*t*)	1.51	4.88	4.34	22.2	-7.72	-0.82	-0.15	-0.02	0.16	0.72	10.7	26.5	37.1
Excess Money Demand FV (*t*)	1.75	5.53	4.37	22.7	-3.88	-0.36	-0.14	-0.02	0.19	0.86	12.6	30.5	53.7
Currency Returns (*t*)	0.02	3.46	-20.6	750	-25.8	-9.58	-5.18	-1.88	0.04	1.97	5.26	8.95	22.2
Carry Trade (*t*)	0.10	0.32	224	1,280	-0.88	-0.40	-0.25	-0.06	0.01	0.20	0.75	1.22	3.48
1-Month Momentum (*t*)	-0.05	3.40	-73.2	783	-28.5	-10.2	-5.18	-1.86	0.04	1.92	5.07	7.82	16.7
3-Months Momentum (*t*)	-0.10	5.98	-83.0	826	-52.6	-17.4	-9.70	-3.16	0.12	3.26	8.76	13.5	29.0
12-Months Momentum (*t*)	-0.07	11.8	-41.7	499	-78.4	-30.4	-19.6	-7.07	0.12	7.20	18.0	28.1	36.3
Filter Rule Combination (*t*)	1.06	0.32	0.00	0.00	0.36	0.41	0.53	0.81	1.06	1.31	1.57	1.68	1.75
Dollar Exposures (*t*)	0.58	1.12	-0.77	1.98	-1.83	-1.58	-1.35	-0.73	1.07	1.42	1.80	1.93	2.07
Term Spread (*t*)	0.28	1.82	-33.8	878	-15.7	-4.20	-2.48	-0.73	0.29	1.27	3.12	5.19	12.0
Output Gap (*t*)	-0.75	7.79	-64.3	652	-39.8	-26.3	-15.8	-3.26	0.23	3.12	9.88	17.5	42.6
Currency Value (*t*)	1.93	23.7	17.0	223	-79.2	-42.3	-33.5	-17.2	0.13	20.7	43.2	51.2	64.8
Taylor Rule (*t*)	-0.09	4.01	-52.1	631	-20.4	-12.8	-7.48	-1.52	0.31	1.89	5.63	9.61	23.0
Inflation (*t*)	0.21	0.48	174	1,654	-1.54	-0.81	-0.47	-0.07	0.19	0.40	1.01	1.82	6.30